THE EAST AFRICAN AGRICULTURAL JOURNAL

of

KENYA TANGANYIKA UGANDA AND ZANZIBAR

Vol. IV—No. 1

JULY
1938

IN THIS ISSUE:

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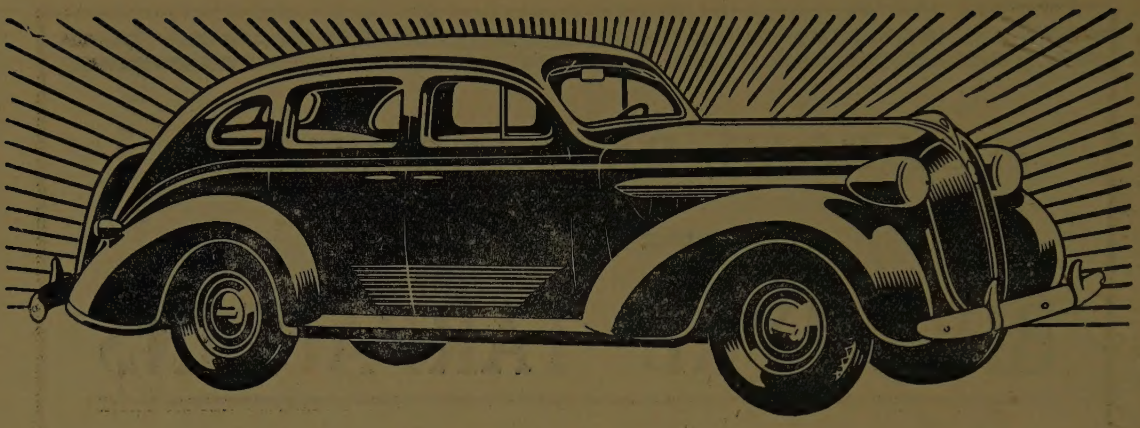

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THE EAST AFRICAN AGRICULTURAL JOURNAL

Vol. IV JULY, 1938 No. 1

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THE EAST AFRICAN AGRICULTURAL JOURNAL

Issued under the Authority of the East African Governors' Conference and published every other month
JANUARY, MARCH, MAY, JULY, SEPTEMBER, NOVEMBER

Subscription 5/- per annum, or 1/- per copy, post free, payable through any Agricultural Officer, or to the Government Printer, P.O. Box 128, Nairobi, to whom all business communications should be addressed. (Subscribers are advised to remit postal orders in payment, otherwise bank commission must be added in the case of cheques.) Editorial correspondence should be addressed to the Editor, Amani, via Tanga, Tanganyika Territory.

Matter submitted for publication should preferably be sent through the local member of the Editorial Board. Manuscripts should conform with the recommendations contained in *Notes for Authors*, which may be obtained from the Government Printer, Nairobi, or from a member of the Editorial Board.

Twenty-five separates of original articles will be sent free to authors. Additional copies can be supplied on payment if application is made at the time the manuscript is submitted.

Readers are reminded that all agricultural inquiries, whether they relate to articles in the Journal or not, should be addressed to the local Director of Agriculture, and not to Amani.

Restrictions on the Import of Plants

The farmer and the gardener owe much to those pioneers who, often against great difficulties and after disappointing failures, have introduced species and varieties of plants into a new country. To establish a new crop plant or a new variety of an existing crop plant is a contribution to a country's advancement; to establish a new garden plant is at least to add to its amenities. That either step should be subject to prohibition or hedged with troublesome conditions must often have appeared a mere vexatious whim of bureaucracy.

It is, however, hardly necessary in these days to argue the case for restriction. The reason for it—to prevent the introduction of injurious pests and diseases—is probably now well appreciated by all concerned; and most readers must be acquainted with instances where the accidental introduction of a pest or disease has played havoc with an agricultural industry. Furthermore, familiarity has no doubt bred resignation. From a recent publication by the Colonial Office[1]

[1] "A Summary of Legislation relating to the introduction of Plants into the Colonial Dependencies of the British Empire as at the end of December, 1936."—Colonial No. 141, 1937, 65 pp.

we learn that restrictive regulations are in force in every country of the Colonial Empire, except only in Somaliland, Aden, Hong Kong, Gibraltar and the Falkland Islands.

This is a valuable publication, particularly for the technical officer concerned with the import and export of plants. It summarizes in sixty-five pages all legislation in force in 1936 in the Colonial Dependencies. Unfortunately the section on East Africa is already obsolete, since it is only since the paper was prepared that new uniform legislation has been adopted in these countries.

Although the objects of plant-importation restrictions are probably generally recognized, it is doubtful whether the extent of the dangers is fully appreciated. We are coming to realize that *every* plant, whatever its species, may be a potential danger to established agriculture. For example some diseases, particularly those caused by viruses, have a wide host range; and in some plants the symptoms produced may be so insignificant as to pass the closest inspection. Yet given the right environment the virus may spread to other plants with devastating effect.

Undoubtedly the safest course is total prohibition and with certain species of plants this course is often adopted. The next best is quarantine of the imported plants. The other possible precaution, and the only one it is often practicable to adopt, is inspection and disinfection at the port of entry. This is the least reliable safeguard because the plants often arrive in such a condition that many diseases must inevitably escape detection by even the most meticulous inspection, and disinfection is not infallible.

It is well to explain what we mean by quarantine. It is the procedure of growing the plants in isolation from other plants that could contract a disease from it, *under frequent inspection by a qualified specialist*. This last condition is the essence of quarantine. Merely to isolate the plants is insufficient. To be effective, quarantine requires that an imported disease be recognized at an early stage. If left uninspected, the plants will increase and with them the disease; effort and money will be expended on their maintenance and propagation; and eventually when the disease is discovered, destruction will entail a heavy loss. The importer of a plant has no legitimate complaint when he is required to conform to stringent conditions; but he is entitled to expect that his efforts after the plants have reached the country shall not be needlessly wasted.

For this and other reasons we believe that the import of plants must come more and more to be taken out of the hands of private individuals and performed by Government. The recognition of this principle is shown by the establishment of a central quarantine station under the control of the Amani Research Station. If Government undertakes the importing, the material in due course becomes available to all the public that it serves. To the man of initiative this may appear an unfair arrangement, for he may claim that he is entitled to some competitive advantage as a reward for his foresight in introducing a new plant. To this complaint there is a definite answer. With every imported plant there is the risk of importing a dangerous pest or disease. That risk is borne by the whole farming community. The whole community, therefore, is entitled to any benefits that may come from running the risk.

H. H. S.

In Memoriam

The aeroplane accident at Singida on the 7th June robbed East Africa of two striking personalities and indefatigable scientific workers. Mr. C. F. M. Swynnerton, C.M.G., Director of the Tanganyika Tsetse Department, and Mr. R. D. Burtt, Botanist, had in the course of many laborious journeys gained a unique knowledge of the country. It is to be feared that much of it will die with them; for both had been too occupied with field-work to publish more than a part of all they had learnt.

Mr. Swynnerton was an outstanding example of a man without the conventional scientific training, and with no degree, who by sheer aptitude and devotion to natural history gave himself a breadth of knowledge and of outlook that, without his peculiar genius, no academic education could have engendered. After twenty years in Rhodesia as storekeeper, artist and farmer, during which he found time to do a great deal of first-class natural history, his appointment as Game Warden in Tanganyika (1919) led at once to the line of work that brought him an international reputation. The magnitude of the tsetse problem was at first not generally realized; the organization he began to build up was more than once in danger of destruction on financial grounds; and it is a bitter irony that when at last ample funds had been secured for his projects his driving force should be withdrawn. It is some consolation to his friends that he lived to write his "Tsetse Flies of East Africa"*, at once a compendium, an inspiration and appreciation of his co-workers.

From the first he insisted that reclamation should not proceed without research. No one could have been more ready to experiment with untried methods, but he had no use for the crude nor for the hit-and-miss. It is characteristic of him that before attempting to control tsetse by annihilating game, he initiated what is perhaps the first scientific study of the movements and the food preferences of game animals living undisturbed.

The breadth of Mr. Swynnerton's interests is obvious from the nature of his scientific publications and other activities. While still farming he produced excellent papers on the local birds and plants; and he made a long series of classic experiments on the food preferences of wild birds, with especial reference to the value of presumably protective characters. He sent to the United Kingdom large collections, which included, among other new species, three coffees. One, which he himself described only two years ago, he named *C. salvatrix,* because he hoped the immunity from *Hemileia,* that he had observed in it round his own farm, might through the medium of the plant-breeder relieve the coffee-planter of one of his plagues. He recently sent seed of this and of another of his new coffees to Amani. While he was in Rhodesia he was financed by the local Department to carry out trials with coffee and other crops, and he was offered the post of Director of Agriculture, Mozambique.

Mr. Swynnerton combined in a remarkable degree scientific imagination, artistic ability and practical knowledge, all applied with that blazing personal energy which took no account of his own age. He was embarked on a plan of immense importance to the agriculture and economics of East Africa; and he was closely concerned with the methods

*For notices in this *Journal* see Vol. II, p. 340 and p. 411; Vol. III, p. 401.

by which the population returning to the areas he had made habitable should use them to the best ultimate advantage.

A more personal appreciation, written by a member of the Tstetse Department, appears below.

R. E. M.

It is difficult to realize that we shall see Mr. Swynnerton no more—his was such a vital spirit, so very much alive that it is impossible to think of him as gone. No one who knew him could fail to be captivated by his boyish enthusiasm, his keenness and cheerfulness. He leaves a blank in the department that can never be filled. His officers will treasure in their memory intensely interesting days spent in the bush when not an animal, bird, insect or tree escaped his notice. His vast store of knowledge was the despair of those who aspired to attain his level. He was an extremely hard worker and it might have been thought that his private life would have been crowded out by the multitude of his official activities. But that was not so. On many a post day when he was involved in a sea of mail, he has found time to mention to the writer some incident about which he was writing to Mrs. Swynnerton or in connexion with his sons' careers. Innumerable friends all over Africa will extend their deepest sympathy to Mrs. Swynnerton and her three sons.

B. D. Burtt met his death with his director with whom he had worked ever since 1925. Burtt's was a cheery disposition which made for him a host of friends all over the Territory who will sadly miss him. It is tragic to think of this promising career cut short.

There is something fitting in the manner of their death. Neither were officemen; both loved passionately the out-of-doors and they went to their death in that wild country between Singida and Dodoma—the real Africa which they both loved and served so well.

S. N.-B.

Cotton Research at Barberton

By E. W. GADDUM, *B.Sc. (Lond.), A.I.C.T.A., Agricultural Officer, Department of Agriculture, Kenya Colony*

INTRODUCTION

The writer spent six months of 1937 studying cotton problems at the Empire Cotton Growing Corporation's Station at Barberton, in the Transvaal, South Africa. As many of the problems which are being investigated there are identical with, or similar to, those affecting the cotton grower in East Africa, it was thought that a brief account of the work at Barberton would be of interest.

It is, of course, to Barberton that we owe the well known U/4 cotton, the derivatives of which have been so successful in East Africa. Selection is still being done on the U/4 families and, owing to the adaptability of this type to a wide range of conditions, is of practical interest to East Africa. Similarly the work at Barberton on cotton bollworms and stainers and on crops grown in rotation with cotton deals with problems of mutual interest.

ORIGIN AND DEVELOPMENT OF THE COTTON STATION

In 1924 the cotton industry of the Barberton District and other low veld areas was in a desperate state, mainly due to low yields. The local varieties such as Improved Bancroft, Zululand Hybrid and "Uganda" suffered very severely from jassid attacks and it had become urgently necessary to overcome this difficulty if the industry was to be saved from collapse. Accordingly the Union Government invited the aid of the Empire Cotton Growing Corporation, and the Barberton Experimental Station was started in 1924, with financial assistance from the Government. Later, in 1928, the Station was handed over to the Corporation, which agreed to maintain it with the help of an annual grant from the Government.

Mr. Parnell started selection work in 1924, and in 1925 he discovered a plant, which he named U/4, amongst the "Uganda"* selections. This plant, though a good cropper, was by no means perfect. Mr. Parnell describes it as follows:—

> "It was smaller and more compact than the general run of Uganda plants, with small leaf and fine wood. It was only slightly affected by jassid, even towards the end of the season, and at the same time carried a very good crop for a small plant. The boll was small, 4.3 gms. boll weight, compared with a mean of 6.6 gms. for Bancroft and 5.5 gms. for Zululand Hybrid selections; moreover the lint was short, 28 mm. compared with an average of about 30 mm. for the whole lot of selections. Both these characters were marked down against it, but it was too good in other ways to be discarded." [2]

In 1926 a progeny row of 250 plants was grown; further single plant selections and a special bulk of 35 plants were taken. Thereafter, owing to the urgent need for an improved variety, it was decided to bulk this strain rather than to spend further time in securing greater homogeneity. The subsequent early history of U/4 may be summarized as follows:—

1927. One acre of special bulk, 475 lb. of seed taken.

1928. Bulked on a few farms, small plots, about 10,000 lb. of seed.

1929. Bulked on many farms, large plots, about 275 tons of seed.

*The origin of the variety of cotton known in South Africa as "Uganda" is not known.

TABLE 1

Locality	Season	Seed Cotton Lb. per Acre: U/4	Seed Cotton Lb. per Acre: Local Variety	Name of Local Variety
Barberton, E. Transvaal	1927–28	830	335	Improved Bancroft
	1928–29	1,012	303	
	Mean	921	319	
Bremersdorp, Swaziland	1927–28	1,055	544	Uganda
	1928–29	1,226	467	
	Mean	1,141	506	
Magut, Zululand	1927–28	780	431	Zululand Hybrid
	1928–29	903	621	
	Mean	842	526	

Some indication of the superiority of this variety over local varieties is given in Table 1. [1]

Since 1924 the work undertaken at Barberton has increased considerably in scope so that at present a staff of seven Research Officers are working under the direction of Mr. Parnell; four are engaged on plant breeding and field experiments and three on insect pest control. In addition, substations have been opened at Bremersdorp in Swaziland and at Magut in Zululand. These stations are valuable for the testing of varieties under a wider range of conditions than is possible at Barberton and as an insurance against loss of seed through hail, insect pests or some other misadventure.

The farm at Barberton is 512 acres in size, with about 168 acres in cultivation. Windbreaks of *Cassia siamea* have been established, dividing the land into blocks of 10 or 15 acres. The farm is situated partly on a granite soil, which is typical of the district, and partly on a deep red loam derived from diorite. The normal planting month is November and the cotton is usually uprooted in early August. The average annual rainfall since the station started is 24.39 in., of which 19.71 in. occur in the period November 1st to April 30th. The altitude is 2,700 ft. and the climate during spring and summer is hot and relatively humid; during late autumn and winter the weather is much cooler and drier. It is not uncommon for cotton planted on low-lying land near a river to be nipped by a light frost during the winter months.

Cotton Breeding: General

The type of cotton being bred at Barberton is one that can be relied on to give a high average yield over a number of seasons and under varying conditions. Selected plants must show a good average quality for a number of characters rather than excellent quality for one or two characters coupled with a poor or mediocre performance in others. The type of plant most favoured is compact and of moderate size; it is capable of making a good recovery after a setback and able to withstand drought periods successfully;

it has the hairy leaf usually associated with jassid resistance. The U/4 type sets a comparatively large number of medium sized bolls rather than a few large bolls. This character is associated with good powers of recovery from a bollworm attack or other setback. Early maturity is a desirable feature but mid-season and late varieties are also being bred for areas where these types are desired.

The seed cotton of a plant selected in the field is subjected to a series of laboratory tests to determine its yield, boll weight, seed weight, lint length and uniformity, and ginning percentage. After the picking is complete a further field examination is made in order to make final notes on the vegetative characters of the single plant selections. When judging plants these final notes are considered in conjunction with the laboratory analysis. For example, it will be found that some of the plants which have shown up well in the laboratory tests owe at least part of their success to the fact that they were growing next to a gap or in an edge row or in a good patch of soil, and allowance must be made for such factors before a final estimate of the plant's capabilities can be made.

The general method of breeding is by the selection and selfing of single plants from progeny rows. The seed from selfed bolls is kept separate from that of naturally opened bolls, the selfed and natural seed being planted in adjacent plots the following year if there is insufficient selfed seed. Selections are made only from the selfed rows except in special cases. Following the selection of single plants from progeny rows, small special bulk lots, approximately 20 per cent of the whole plot, are taken. These special bulks act as a useful reserve of material for future selection work if, perchance, the initial single plant selections from the plot fail to justify their selection. Part of the special bulk seed is used for variety trials and for multiplication and observation plots throughout the district.

If a strain has proved itself superior to the varieties at present in cultivation, seed bulking is undertaken with the aid of local farmers and the new variety is eventually released for general cultivation. During all this time a careful watch is kept on the new variety for rogues, which are removed whenever they appear.

Some work is also being done on the crossing of varieties, but the amount of breeding by this method is smaller than that by selection. By crossing the U/4 type with the extremely jassid resistant Cambodia cotton and back crossing with U/4 it is hoped to secure increased jassid resistance allied to the high yielding qualities of U/4.

In the 1936-37 season forty strains were being tested in variety trials. These are being tried against 052, the variety at present in general cultivation locally. In addition there were 500 progeny plots containing 1,585 single plant selections. The high cost of native labour for selfing, etc., is a handicap in this work.

Cotton Breeding: Technique

Acid Treatment of Seed.—All seed for multiplication plots, observation plots and variety trials is treated with sulphuric acid to remove fuzz. The advantages of acid treatment are:—

(1) By removing fuzz it is possible to get rid of bad and damaged seed by floating in water.

(2) Germination is quicker and more even.

(3) Delinted seed is easier to handle when planting.

Variety Trials.—These take the form of randomised blocks. A uniformity trial is in progress to determine the best layout for cotton trials and results up to date confirm previous experience that

the long narrow type of plot gives the best results. At present plots are 7 ft. (two rows) wide and 78 ft. to 90 ft. long. A trial of, say, ten varieties requires 10-16 replications to produce the requisite degree of accuracy. All results are expressed in terms of lb. of lint per acre; this necessitates finding the ginning percentage of each variety for each picking, and converting the yields of seed cotton into yields of lint.

Flower Counts.—Flower counts are made daily during the flowering season on sample areas of the chief varieties under trial and the results are expressed as the number of flowers opening per plant per week. These figures furnish a useful guide to the earliness of varieties and their relative vigour during the growing period. If the crop suffers from hail or some other misfortune which renders the final yield figures valueless, the flower count records will enable some estimate of the relative capabilities of the different varieties to be made. A comparison of flower count figures with final yields gives an indication of boll shedding due to physiological and other factors. Flower counts are made by native female labour, using tally counters, in charge of a European. They soon learn the use of tally counters and give reasonably accurate counts under adequate supervision.

Jassid Counts.—Varieties are tested for jassid resistance by growing them in plots with strips of the very susceptible Improved Bancroft in between each plot to secure adequate infestation. Weekly sample counts of jassids are made and the results interpreted statistically.

Selfing.—This is done by female labour in the afternoons when the flower buds are extruded. A brass wire, one end of which has been twisted into a conical shape by wrapping round a pointed stick, is fitted over the flower bud so that the cone encloses the unopened bud; it is fastened in position by pushing the free end of the wire through the subtending bract and twisting it loosely round the peduncle or fruiting branch. Self-fertilization takes place during the following day and, after a few days, the wire is removed and the peduncle tagged with red wool. Inefficiency is soon detected by observing the number of flowers which open naturally the following day.

FIG. 1
A selfed cotton flower, showing method of selfing.

Picking Single Plant Selections.—In picking the single plant selections it is necessary to keep the cotton from the selfed bolls separate from the unselfed bolls. The selfed cotton is put into a brown-paper bag which is kept inside the cotton bag provided for the "natural" seed cotton. In order to determine boll weights it is necessary to pick a number of bolls and wrap their contents separately in tissue paper.

Ginning Percentages.—A hand-driven roller gin is used for this work. As the ginning percentage of a cotton varies appreciably according to the season and also to whether the sample was picked early or late in the season, it is very necessary to secure representative samples.

Boll Weight.—This is the average weight of seed cotton per boll and is determined from a sample of 12 to 20 bolls.

Lint Length.—A sample of five seeds is taken for each single plant selection and the lint of each seed carefully combed to either side of a parting which follows the long axis of the seed. The combed seeds are arranged on velvet pads and six lint measurements are made from the centre parting, three on either side. The mean of these measurements is taken as the lint length of the seed. The

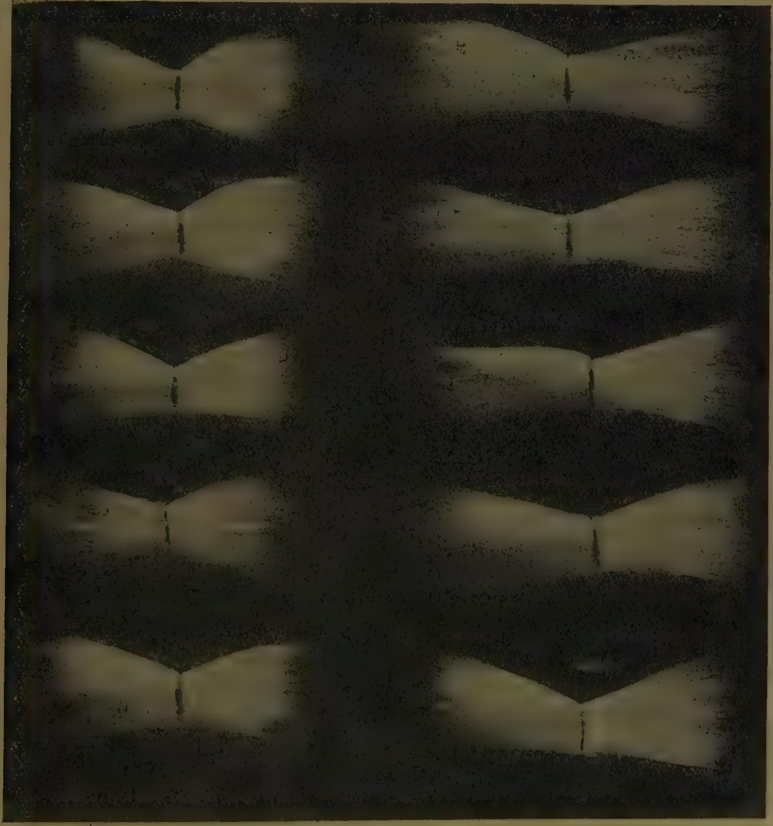

FIG. 2

Combed cotton seeds from two single plant selections ready for lint measurements. The sample on the left is from a very short-linted plant (average of 25.4 mm.) and the lint lacks uniformity; note the "butterfly" effect which is well seen in the top two seeds, due to unevenness in lint length. The lint length of the right-hand sample averaged 34.4 mm., a very good length.

Seed Weight.—This is expressed as the weight, in grams, of 100 seeds. A heavy seed weight for a variety is an indication of vigour. Moreover the seed weight is an important factor in the ginning percentage and these two characters are always considered together.

measurements can be made with a pair of dividers but trials are being made this season with a celluloid measurer which can be placed over the seed. Besides recording the lint length a note is also made of its degree of uniformity.

Cotton Cultivation Experiments

Under this heading are included a number of investigations of which only a few can be briefly mentioned here.

Trials are being carried out with a view to finding the optimum number of seeds to be planted per hill. This affects the optimum time of thinning and the two factors are being considered together.

Fertilizer trials are in progress on both the loam and granite soils and are yielding results of importance, especially to local farmers.

One of the most interesting lines of work is the investigation of suitable crops to be grown in rotation with cotton. The following are being tested: sunflowers, tepary beans, cotton, maize and soya beans. Cotton yields best after a fallow; well after sunflowers or tepary beans and poorly after soya beans on the loam soil. Cotton following cotton and cotton following maize usually occupy an intermediate position. Differences in the moisture reserves left by the various rotation crops may have their effect; but it has been shown that this is not the only reason for differences in growth and yield observed in the succeeding cotton crop. A curious fact is that cotton following a fallow always makes a slow growth in the early stages although the final size of plant and yield is superior to all other treatments.

Entomological Work

It should be mentioned at the outset that at present there is no legislation in the Barberton District enforcing a close season and forbidding ratooning. Most of the local farmers now realize the importance of such legislation but, until it comes into force, the work of insect pest control is rendered much more difficult.

Bollworm Investigations.—The following species of bollworm (in order of their economic importance) are found at Barberton:—

Heliothis armigera: The American Bollworm.
Diparopsis castanea: The Red Bollworm.
Earias insulana: The Spiny Bollworm.

By means of regular observations of eggs, larvae, parasites, predators, etc., of American bollworm on sample areas containing all the known cultivated and natural hosts, a wealth of information has been gathered on the following important points:—

(1) The ecology of the pest is now known fairly accurately. Although it occurs to some extent on natural hosts, the main source of infestation is cultivated plants and weeds on arable land.

(2) Plants are only attractive to the egg-laying moth during their flowering periods.

(3) The egg-laying moth exhibits marked preferences in selecting plants for oviposition; for example, both maize and Chick pea (*Cicer arietinum*) are more attractive than cotton.

(4) The mortality rate of the larvae and also the size and fecundity of the moths are influenced by the kind of crop on which the larvae feed, e.g. the larval mortality is greater on maize than on Chick pea.

These conclusions suggest the desirability of finding the most suitable alternative food crop of the bollworm for incorporating as a "trap" in a planting programme, and detailed work is being done with this object. Bollworm investigations are being carried out on a wide front by means of field observations, including observations on caged specimens, records of crop climates, a chemical investigation of the nature of

the attraction of the plant to the egg-laying moth, the use of insecticides, the influence of parasites and predators, the influence of the condition of the crop.

The control of Red bollworm is greatly simplified by the fact that it appears to have only two natural hosts, *Cienfuegosia Hildebrandtii* and Wild Cotton, *Gossypium herbaceum* var. *africanum*. Since neither occurs generally or near Barberton a large measure of control is obtainable by a rigid adherence to close season rules.

Red bollworm investigations are being carried out at Bremersdorp and Barberton. They follow the same general lines as the American bollworm work, i.e. regular field observations supplemented by detailed field and insectary experimental work.

Spiny bollworm does little damage and, provided close season practices are followed, there should be little to fear from this pest.

Investigations on Internal Boll Disease.—Research is being carried out along two main lines:—

(1) The reduction of the insect vector population.

(2) The reduction of the effect of an attack by those vectors.

A detailed study of the ecology of cotton stainers is of fundamental importance to the first line of research. This involves an investigation of the food cycle by means of a survey of the population and distribution of stainers and their natural hosts. An understanding of the effect of climate on stainer populations is also of importance.

The ecological work, which is being done in collaboration with workers in the Rhodesias and Nyasaland, has shown the situation to be as in Table 2.

The relationship of the main hosts to vegetation types is well known in N. Rhodesia and S. Africa, fairly well known in Nyasaland and roughly known in S. Rhodesia.

The ecological and general meteorological work is being backed up with experimental work in the field, insectary and laboratory. Under this heading may be mentioned the study of host plant climates and their effect on stainers, also the effect of different foods on stainers.

Work on the second main line of research, i.e. the reduction of the effects of an attack, led to a study of Internal Boll Disease and the means of distinguishing it from Bacterial Boll Disease not transmitted by insect vectors. Some study has also been made of the incidence of *Nematospora* spp. on the natural hosts of stainers. Various problems affecting the transmission of the causative organisms have been and are being investigated. For example, it has been shown that

TABLE 2

Species	Main Hosts	Geographic Range as Important Species
D. fasciatus ..	Baobab. *Thespesia Rogersii.* A few *Hibiscus* spp.	N. Transvaal, N. and S. Rhodesia, Nyasaland generally.
D. superstitiosus ..	Confined to herbaceous Malvales, particularly annual *Hibiscus* spp.	N. Rhodesia and possibly fringing S. Rhodesia and Nyasaland.
D. intermedius ..	Sterculiaceæ. Herbaceous Malvales.	S. Rhodesia and Rift Valley of N. Rhodesia and Nyasaland.
D. nigrofasciatus ..	Chiefly perennial herbaceous and a few special arboreal Malvales.	Zululand to N. Transvaal.

other insect vectors besides *Dysdercus* are implicated and these are being studied. It has been shown that *Nematospora* spp. do not persist in stainer nymphs from one instar to the next. This suggests that there is no cycle within the stainer.

Work on the physiological effect of staining on the lint and seed has been started. In this connexion it has been shown that the extent to which a boll is damaged is largely determined by its age when infected.

With regard to control measures hand collection has not so far been proved practicable. The breeding of parasites or predators does not appear to hold any promise of success and the eradication of natural hosts, in the Barberton District at any rate, is quite impossible.

The ecological work and records of stainer populations in cotton emphasise the importance of enforcing a close season, especially in the control in the Barberton District of *D. fasciatus* where its status as a pest is dependent on ratoon and standover cotton.

The practice of growing ratooned and plant cotton in the same area is considered unsound. The ratooned cotton, being more advanced than plant cotton, attracts stainers earlier in the season. The stainers breed in the ratooned cotton and eventually overflow into the plant cotton in overwhelming numbers. It has been proved, by marking stainers in a ratooned field, that plant cotton at least ten miles away may become infested by migrating stainers. It is probable that legislation forbidding ratooning would materially benefit the farmers of the Barberton District.

The above control measures aim at the reduction of the stainer population; work on the means of reducing the effect of stainer attack is not so advanced and cannot as yet suggest practicable control measures.

ACKNOWLEDGMENTS

The writer wishes to thank the staff of the Cotton Experimental Station at Barberton for valuable assistance and advice in the preparation of this article.

Thanks are also due to Mr. W. L. Fielding for permission to reproduce Fig. 1.

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[2] F. R. Parnell (1935)—"The Origin and Development of U/4 Cotton," *Empire Cotton Growing Review*, XII, pp. 13-182.

Essays in Applied Pedology

III—Bukoba: High and Low Fertility on a Laterised Soil

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AND INCLUDING A NOTE ON SOIL FERTILITY AT NYAKATO

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Bukoba is a small township and lake port in Tanganyika Territory, on the west coast of the Victoria Nyanza, twenty-eight miles south of the point of entry of one of the principal Nile head-waters, the Kagera River. The name is also that of an administrative district, which lies between the Uganda border on the north and Biharamulo District on the south and runs west to the Belgian mandated territory of Ruanda, adjoining it along the middle course of the Kagera. Bukoba District thus includes in its western half the long low-lying valley of the Mwisha River and the highland of Karagwe. The easternmost part of the district is however the part with which the present essay is mainly concerned: a strip of humid ridge-and-valley country twelve to sixteen miles wide running down the lake coast from latitude 1°S. to 2°S., i.e. for about seventy miles.

This area of about a thousand square miles, comparable in size with one of the smaller English counties, contains 230,000 rural inhabitants. The only townfolk, those in Bukoba itself, number less than 2,000. The density of population reaches 1,230 per square mile in one of the sub-chiefdoms. In five others it exceeds 400 and over the remainder of the area it averages 180*. Thus in the most crowded parts each family, reckoned at five persons, is supported by only 2.6 acres, and in the least crowded parts by 17.8 acres on the average. For East Africa such figures represent very close settlement.

The people are the Bahaya, banana-eaters and to a limited extent cattle-keepers. They live in family units on permanent heritable holdings, each house and attached quarters for cattle standing hidden in its banana-grove. A group of adjoining holdings is marked as a feature in the landscape by its aggregate stand of bananas, sharply limited against surrounding larger stretches of unenclosed treeless grassland. These banana-grove "villages" may partly fill a valley alongside a stream, or may form the skyline on a high ridge, or may occupy middle positions on slopes, with open ground above and below. The intervening lands are mostly grazing commons, but patches of them are tilled. Many of the ridges end in sandstone bluffs and scree-slopes, and these outcrops of rock render a proportion of the land agriculturally untenable. The main river-valleys and valley junctions contain considerable areas of permanent swamp, some parts of which are papyrus, some are tussocky grassland on peat, and some carry blocks of dense evergreen swamp-forest. There are small remnants of rain-forest on the steep sides of certain ridges.

The banana as staple food-crop is interplanted with beans and other minor annuals and perennials. Amongst the cul-

*Calculated from Mr. C. Gillman's *Population Map*, see reference [1].

tivated perennials, from time immemorial there has been a coffee—a Robusta coffee, a form of *Coffea canephora* indigenous in the district and now known as *bukobensis*—its berry was originally used not as a beverage, but for chewing. European influence began with the building of the military station of Bukoba on the lake shore by Emin Pasha in 1890, and between Emin's own botanical interests and those of his lieutenant on the expedition, Franz Stuhlmann (later a joint founder and the first director of the Amani Research Station), a coffee in common cultivation by the natives naturally attracted attention for its economic possibilities. Stuhlmann records [2] (p. 138) that in November and December 1890 Emin caused large numbers of young coffee trees to be brought in by the local villagers and had them planted, each protected by a reed fence. This first trial planting was in the open in the precincts of the military settlement; it was not a success, and presently the garden was laid out afresh in a nearby patch of forest on a steep declivity, from which only the underbrush had been cleared. It again failed, the site this time being too moist in the wet season. Finally it was established in a banana grove. Thus early were ecological mistakes made and lessons learned—though not always remembered during the great extension of coffee planting that took place later.

Under the German administration small shipments of coffee for export began after the opening of the Uganda Railway, and rose to a few hundred tons. There was some allocation of land to Europeans, but the area of European-owned coffee has always remained small; it totals about 500 acres. Arabica coffee was introduced alongside the other and now, harvested separately and marketed as "plantation" coffee, though in fact mostly native-grown, forms about one-third of the total. New plantings were encouraged by the British administration after the war, and together with the effects of replanting, regeneration of old trees, and important improvements in hygiene for pest control, brought the exports to a peak of nearly eleven thousand tons in the year 1935; at which level the output from Bukoba (almost entirely from eastern Bukoba, the contribution from Karagwe being small) formed one quarter of the whole production of coffee from Tanganyika, Uganda and Kenya combined. A big drop to 6,500 tons in 1936 is attributed to "adverse weather conditions and the normal decrease in production which follows years of heavy cropping [3]; but it would seem doubtful whether all the expansion of recent years has been on a stable basis. Although the Bukoba product does not compete in the higher price classes for coffee and the recent years of large output have been a period of falling values (thus 7,800 tons in 1928 sold for £478,000, while 10,900 tons in 1935 brought in only £249,000), nevertheless the Bahaya nowadays have a cash income which places them well above mere subsistence level. They can afford, or could at least during the years of better prices, to hire migrant casual labour from Ruanda for the hard work of digging; they supplement their staple farinaceous food by purchases of slaughter cattle from Sukumaland across the lake; social services progress by Native Treasury expenditure; a good deal is spent on imported manufactured goods, and the chiefs own cars.

It would seem then that this Lake-coast strip, well watered, densely populated and modestly prosperous, must have a soil of fairly high fertility, or at least that it is cultivated by enlightened and intensive agricultural methods that are well worth study. The first of these inferences is true of those parts of the

ground that are actually the seat of the bulk of the production, but this in turn is so only because of a measure of truth in the second. The fertility of the soil in eastern Bukoba as determined by natural factors is actually low, but it appears to have been concentrated on blocks of initially more eligible land which form only a fraction—perhaps one fifth or less—of the total area. Outside these blocks (the banana gardens) expansion is deterred by an unusual degree of infertility, which for some crops amounts to complete barrenness.

Though there are wide areas of little-used land almost everywhere, and on much of this the soil is sufficiently well drained and deep to be eminently cultivable, yet there is a land shortage. The Provincial Commissioners' Reports [4] refer repeatedly to the existence of a social problem of "landless youths", who while awaiting their inheritance of the family holdings are disinclined to develop new ground for themselves. The explanation given is that "the real difficulty is not lack of land but lack of initiative or of agricultural ambition on the part of the younger generation". "It is a matter of some difficulty to get these boys to understand the urgency of the position, and to make use of the hoe." The blame is, however, perhaps unfairly laid by such statements. Initiative and ambition can hardly be expected of the juniors of the tribe when they are faced with technical difficulties that are quite beyond resolution by themselves unaided. The problem of land shortage is bound up with the whole system of rural economy that has grown up in adaptation to the natural conditions, and in particular to the fact of a regionally poor soil.

The natural conditions therefore deserve analysis. In what follows I attempt an examination of the factors of soil and of soil management in the area, with regard particularly to the problem of extending the boundaries of the present relatively small enclaves of fertile land.

The Bukoba Soil and Exhausted Residue

It has been stressed by Gillman in his geographical studies of East Africa [1 and 5] that supplies of water for domestic use, which are a first necessary condition for human settlement, in fact govern population density more than any other single ecological factor. It is certainly true that scarcity of permanent water will compel a tract of rich soil to be left uninhabited, except by an advanced community that organizes water supplies from a distance—as (so we read) has been done in Persia since ancient times by the building of elaborate underground conduits. The converse, that an abundance of water will enable a poor-soil region to be intensively worked, is true only if each cultivator is not to be dependent solely on the original fertility he finds in his own patch. In this case it is the plant nutrients, not the water, that must be brought from a distance and conserved.

The necessary condition of plentiful water supply is fulfilled in eastern Bukoba, where perennial streams and hillside springs are fed by a well distributed and (in total) fairly reliable rainfall of about 1,900 mm.* (75 inches). Only the month of July is sometimes rainless. A two-months' total of 700 mm. falls in different years in February–March, March–April or April–May. There is another peak of about 250 mm. in November or December, and all other months

*Twenty-six years' records at Bukoba town (not including the war and immediately post-war years) average 1886 mm., with a least total of 1553 mm. and a greatest of 2339 mm. Towards the south of the 70-mile strip, and towards its western margin at 15 miles inland, the rainfall drops towards 1200 mm.

may experience more than 100 mm., though June, August or September frequently fall short. Much of the rain at all times comes as morning thunderstorms, but the soil is absorptive and such water as it cannot retain is rather led to the surface afterwards by impervious strata below ground than shed directly as run-off.

There is, however, in most of our transactions with climate, a point where abundance of rainfall ceases to be an unmixed blessing. In the matter of the climatic effects on soil richness or impoverishment, which now concerns us, the critical point is decided by a number of other things besides the rainfall itself.

The rainwater that enters the ground is both a chemical reagent (a dilute solution of carbonic acid) and a medium of transport of what is dissolved. In regard to chemical effects an important influence is that of temperature. The range of atmospheric temperature is between 17°C. and 26°C. as extremes, but the monthly means lie above or below the annual mean of 20°C. (68° Fahr.) by no more than a degree at any time of the year. The soil temperature under a plant cover probably varies little from the mean atmospheric temperature. Under these equable conditions of moderate warmth, and with the soil never really dry, chemical decompositions proceed steadily all the year round. In regard to transport of the soluble products, we have already noted that the flow to the streams through the soil is liberal and seldom for long interrupted. There is ample opportunity for loss of dissolved matter to the Lake and so to the Nile and Egypt. The total of soluble products lost from these soils in the past could have been very great. The effect of vegetation in controlling these losses by leaching, comparatively as between forest, grass and crops, will be considered presently. To understand the kind of material upon which the losses have fallen, so as to assess the value of what is left, we must next consider the parent rock.

The geological map shows a formation that has been given the name "Bukoba Sandstone." This is thought to have been formed in a continental shallow-water basin having free outlet to the sea, and was built up by the accumulation of sands, and at times clays, that were the breakdown products of older metamorphic rocks lying further west—the Muva-Ankolean quartzites and the shales of Karagwe—and of granites intruded into these. The Bukoba Sandstone consists dominantly of compact fine to medium-grained sandstones, with which are interbedded hard shale-like rocks consisting of a fine aggregate of quartz and sericite, a form of mica. The sericite represents the clay of the original deposits. The formation is intruded by thick sills of dolerite.

The relevant points in this geological description may be amplified thus. The materials that went to the making of the Bukoba Sandstone had already undergone a thorough process of decomposition, denudation and sorting. In so far as they came from the Muva-Ankolean rocks, they had undergone this process twice, for those rocks are themselves ancient sediments. As a result the coarser sandstones consist of practically nothing but quartz grains and cementing silica. There are traces of iron oxide, the feldspars have survived only as occasional crystals, and other soil-forming minerals are represented very scantily. On the other hand the fine-grained flaggy or shale-like sandstones contain, besides quartz, a clay-forming mineral in considerable quantity. A fine yellow-brown mud can readily be produced from the

surface of a weathered specimen of the shaly sandstone by rubbing with a wet finger. The two kinds of sandstone and their intermediates can thus provide, in the derived soils, a range of texture from pure sand to fine-sandy clay, according to the degree to which their products of weathering and denudation have been mixed.

As regards chemical composition, the more soluble constituents of the ancient primary source rocks were lost in the Palaeozoic drainages while the Bukoba formation was being laid down. Such losses would fall with most severity on the chlorine, sulphur, sodium and calcium. The dolerite sills, being primary igneous rock, rank as a source of replenishment, but as the dolerite outcrops occupy a relatively small part of the land surface their contribution to the total soil mass that covers the area must have been rather slight. The sericite of the shaly rocks is a source of one of the major plant nutrients, potash. The status of the Bukoba rocks in regard to phosphate can be assessed on similar lines. The coarse sandstones contain almost none, but the clays that went to form the shaly rocks would carry some phosphate with them from their parent shales and granites, and apatite, a primary source of phosphate, is a usual minor mineral in dolerites.

It is, then, mainly the shaly fine-grained sandstones that will provide useful soil-making material, with some help from the dolerites. The degree to which the breakdown products of these two rock-types occur amongst those of the coarser sandstones is therefore of importance. We must turn to the physical geology and see how the land forms have been modelled and the spoil distributed.

The country consists of broad-topped parallel ridges running north-north-east, rising by gentle gradients and breaking off in bold sandstone cliffs. The flattish tops of the ridges are the remaining parts of a once-continuous surface that had been planed down and levelled up by long erosion and aggradation in the days before the present drainages to Lake Victoria were established. On this surface a mantle of irregularly-mixed detritus had accumulated, derived here mainly from the sandstone, there mainly from the shaly rock, locally from the dolerite, most often from some proportion of all three. Wherever flat-lying flaggy beds occurred just underground, and wherever mature forms of the topography favoured the convergence of sub-soil seepages to an outfall along a contour, sheets and zones of concretionary ironstone ("murram") tended to form.

Presently this senile land surface was heaved up and tilted. The peneplain became a plateau. Along lines of weakness the mass broke and slipped, and fault-scarps were formed, exposing fresh surfaces to weathering. Waters formerly stagnant became coursing streams, which carved new valleys and cut up the plateau into ridges. Tilting continued or was resumed after an interval, and checked the flow of the north-running streams so that their valleys became long swamps, but the easing down of the valley slopes went on and is still proceeding. Where the softer shaly rocks and the dolerites were exposed they have mostly been worn down and concealed by overburden. The harder sandstones yielded more slowly, stood at steeper angles and have in many places remained in view as bluffs or bouldery slopes. Each rock type, whether in view as an outcrop or not, gives rise locally to its own textural type of derived soil, but all have contributed

more or less by transported debris to the mixed covering of the valley sides. The flat tops of the ridges still carry their share of the old mantle of detritus that lay on the former peneplain; the frayed edges of the murram sheets appear at ground level along certain contours near the brow of the valley slopes and have hardened to sill-like outcrops, which the most un-geomorphological traveller cannot but notice nowadays as his car bumps over them towards the top of a long ascent and again as he drops beyond into the next valley. Transported lumps and detrital gravel from these concretionary ironstones are found in the soils at the lower levels.

We must therefore expect variety from place to place in the parent materials of the Bukoba soils, and in many places mixture. Though some of the shallower soils have been formed by the weathering of massive rock in place, the deeper soils must usually be of transported and therefore mixed material. The sculpturing of the surface is still going on and the covering of debris is being slowly shifted, sorted, mixed and readjusted to the evolving land forms as heretofore. Over a short span of years these bulk physical changes are hardly perceptible in a country so well protected by vegetation as is eastern Bukoba, unless indeed erosion is being accelerated by human activities and here such acceleration is not in fact very marked. The total effect of all denudation processes to date is expressed in the present patchwork distribution of the raw materials of soil, but the trends of further gross physical change do not here matter very much.

With chemical processes it is otherwise. We are interested not only in the total effect to date on the parent materials as described, but also in the chemical changes that are still proceeding; for these chemical changes are within man's power to some extent to check or counteract on the lands he occupies.

We have seen that the parent materials had mostly had a long experience of chemical decomposition before they began to form the soils of the present day, and were (except the dolerite) already residues, more or less exhausted. We have seen also that further decompositions are favoured by the prevailing moderate warmth and that leaching is favoured by the rainfall. In such conditions the ruling tendency is towards laterisation. There are continuing losses from the exiguous supply of bases that the parent materials afford, there is destruction of the aluminosilicate clays with loss of combined silica and loss of base-absorbing power, and a residue remains that finally will consist of little but quartz sand, iron and aluminium oxides, and acid humus. This process will have been somewhat delayed in the finer-textured soils because of slower leaching and the existence of a reserve of clay-forming minerals; and it will have been delayed also in limited soil masses to which the weathering of fresh surfaces of dolerite has been contributing a supply of lime and other bases. It will be furthest advanced in the soils that are the most porous because of a predominance of materials derived from the coarser sandstones, and in the soils that have been longest weathered from their parent outcrops of rock—except in situations where secondary clay substance has been rebuilt by the action of silica-bearing ground waters.

The weight of the geological and climatic factors in soil development has thus been thrown heavily in the direction of impoverishment, but we must on several counts reckon with inequalities

in the final effect. These inequalities have been greatly accentuated by man.

Human Influences on Soil Fertility

It is reasonably certain that this piece of country was originally forest-clad. The climate is humid enough to support evergreen high forest and remnants of such forest still exist. When agricultural man first attacked this forest he would find that its stature and floristic composition gave him little guidance on soil fertility. Often, and more often than not, he would be disappointed and would have to move on to a new clearing after a few years' tenure. Gradually most of the area would be worked over by this trial-and-error method until sites were found—the intrinsically most fertile—on which he could settle permanently. On these he developed a system of agriculture of which we have already noted the essential features: permanent heritable tenure, bananas, cattle housed at night, and access to common land for grazing and supplementary crops.

The influences that began to be felt on soil development from this stage onwards can be sketched as follows:—

On village sites and their immediate environs, the circulation of mineral nutrients through forest trees was interrupted, but a substitute circulation of fair efficiency was provided through the bananas, which are deep-rooting and make large demands on subsoil moisture. Circulation would occur to a subsidiary extent through planted trees such as the *Markhamia* used for hedging, the *Maesopsis Eminii* used for building timber and fuel, fruit trees, and perennial bushes including coffee. Losses that would otherwise have been sustained through leaching were thus forestalled. Residues accumulated, partly of outside origin—kitchen refuse, the ashes of fuel cut far afield, cattle droppings. Manure was applied to the bananas. Living banana plants cast a light shade and intercepted the beating of rain. Their fallen leaves and stems provided an effective mulch on the soil surface. Humus was replenished. Intercropping with small annuals, including legumes, gave the benefits that accrue from the practice of "polyculture". The ground was enabled to support an increased, and finally a dense population. In time coffee became a commercial asset, and its sale brought in meat and other foodstuffs of extra-regional origin—whose residues, employed though they are at far less than full effectiveness, accumulate near the houses and further enhance village-site fertility.

Contrast this picture with that for the *inter-village common lands*. The unsuccessful and presently abandoned clearings were nobody's business. At first they reverted to secondary bush, but were cut over repeatedly for fuel. Browsing by cattle and goats kept back regeneration of tree growth. Grassy glades became permanent, fire entered in occasional dry years, the remaining trees were eliminated as building poles and fuel became scarcer, and finally all was open grassland. The soil was originally the poorest, the sandiest, the most highly leached and laterised of what the district afforded. Under forest some stocks of plant nutrients were kept in circulation, but under grass the circulation now is slight and the through-put of drainage-water to the streams is much increased, so that leaching losses are accelerated. The stock-carrying capacity of the land is low, though the bulk of feed remains large; for only the poorer grasses can flourish even though the ample rainfall promotes heavy growth. Increasing soil acidity leads to poor nitrification of organic

residues. The annual turnover of nitrogen is small. The grasses, even in young growth, are low in protein. When the sod is turned for winning a crop, a single year's cropping, even with a legume (usually *Voandzeia*, the Bambarra groundnut), exhausts the land; and only in one year in every eight or nine can this adventure be attempted.

The Infertile Grasslands

The degree of infertility to which the open grasslands of eastern Bukoba have been reduced is indeed a most unusual one. Of the Native Authority Agricultural Sub-station at Nyakato, situated on typical land of this type a few miles north-west of Bukoba town, Mr. A. H. Savile, Agricultural Officer for the Bukoba District, writes in a communication to this *Journal*:—

"A perusal of the reports of the old Nyakato Sub-station reveals that all crops planted thereon failed to produce any yield at all. In most cases the plants failed to pass the seedling stage. The usual symptoms were yellowing of the leaves followed by wilting and death. The only crop which natives had previously succeeded in growing on this land was the "Numbu" yam (*Coleus tuberosus*, Labiatae)—an exhausting crop. Heavy applications of bone meal, blood meal, "meraco" fertilizer (a meat-and-bone meal) and lime failed to produce any improvement. The subsoil pipe drains made from bamboo sections proved unsuccessful as did applications of burned plant residues.

The first indication of the correct line of attack was seen when several cassava plants were noticed to be making normal growth in the midst of a plot of otherwise derelict-looking specimens. On investigation it was found that these healthy plants were grown on the site of a rubbish-pit that had been filled in.

An application of crudely-made compost to several plots of bambarra groundnuts enabled us to harvest our first crop. Much of the subsequent success in dealing with the soil problem at Nyakato has been obtained with low-grade incompletely rotted compost.

Considerable difficulty was encountered in getting the material to break down sufficiently. This may well be due to the very poor quality of the indigenous grasses used in the manufacture of compost at Nyakato. Grasses which were described as being the lowest in feeding value ever analysed at the Royal Veterinary College, Edinburgh [6] are presumably not suited to the production of a high-grade compost. However, in spite of this disadvantage remarkable results have been obtained with what were, admittedly, heavy dressings of compost.

The question then arises as to what is the limiting factor counteracted by such compost—is it a chemical or a physical condition of the soil that has to be overcome before crop production can commence? It would seem that lack of organic matter is the limiting factor and that hence the action of the compost has been a physical rather than a chemical one. This would appear to be borne out by the obvious benefits accruing from banana-leaf or grass mulch throughout Bukoba District."

While by no means disagreeing with Savile about the valuable physical effects of heavy applications of organic matter, especially on such structureless soils as those of Nyakato [7], I do not think that lack of organic matter *per se* accounts for the almost complete barrenness of these soils when cultivation is attempted upon them in their unimproved state. A soil profile from the Nyakato grassland on a plateau site has been found to have 4.6 per cent organic carbon (about 8 per cent humus) in the top six inches, about 3.7 per cent to 18 inches depth and about 0.9 per cent from 18 inches to 4 feet. Other profiles, kept immature by being situated on a steep valley slope, have a 2.6 per cent organic carbon in the top six inches, 2.2 per cent at 12 inches, and 0.8 per cent to 4 feet. Composite top-soil samples from cultivated ground, ex-grassland, have on the average about 3.9 per cent organic carbon. It cannot be said that such figures exhibit a deficiency of organic matter by ordinary standards for grassland under these climatic conditions.

Nor is the organic matter of unusually low total nitrogen content. In no sample amongst many from this area does the ratio of carbon to nitrogen exceed 15.5; the ratios lies mostly between 13.0 and 15.0.

The deficiency seems rather to be a general one in all available plant nutrients, and to be best remedied by emulating the practice that has been adopted unconsciously or at any rate empirically in the old-established banana gardens, and that over many generations has built up their fertility; namely the introduction of residues from outside the piece of land that is to be ameliorated, in quantities greatly in excess of what could be won unaided under grass or bush fallow from subsoil reserves on the land itself. A large bulk of miscellaneous organic matter functions as a vehicle for the introduction of such residues, prevents their too rapid loss by leaching, and in its final state as humus of good base-status is the most favourable medium in which to present them to the feeding roots of a developing crop.

On the existence of a general nutrient shortage in the Nyakato soils the laboratory data leave no doubt, though in the present "reconnaissance" stage of the investigations the picture lacks detail. The soils are deep on the flat ridge-tops (the old plateau surface), shallower and somewhat bouldery on the valley sides. They are medium-fine to sandy in texture, practically structureless, very friable in top soil and subsurface though in places stiffer in the deep subsoil. The acidity of the top six inches is pH 4.7 to 5.2; one sample only has given a figure as near neutral as 5.7. In the subsoil pH varies irregularly with depth, from 5.0 to 4.4, 4.6 being a frequent value. These figures represent a fairly severe acidity and of themselves would lead to expectation of poor fertility for many crops. The clay fractions have silica sesquioxide ratios of the order of 1.25 to 1.1. Exchangeable bases in none of the top soil samples examined total more than 5 mg. equivalents per cent and in some the total is less than 2. In all samples exchangeable calcium is less than 1.5 mg. equivalents per cent; calcium seems to bear an unusually low proportion to potassium and magnesium. There is no direct evidence of shortage of total phosphate below the low level common to many African soils, but in a sesquioxidic soil such as this the phosphate there is will be difficultly available.

The Edinburgh analyses of two species of grasses, referred to in Savile's note above, and to which I have been given access by the courtesy of the Veterinary Officer at Bukoba, have been studied in comparison with analyses of grasses from E. Usambara, a district of gneiss-derived laterised soils. Besides demonstrating that the soil nitrogen is unavoidable, they confirm an unusual degree or deficiency in certain mineral nutrients in the Nyakato soils. They point especially to lack of calcium, sodium and chlorine. In view of the past history of the bulk of the parent materials as continental fresh-water sediments, and the great distance of Bukoba from the sea or from any geologically recorded ancient sea-coast (the nearest is nearly six hundred miles away), it is not surprising that the two last-named elements are in short supply. Whether any other element required by plants in minute quantity is a limiting factor to crop growth in these soils is a question not yet answered, though it is under preliminary investigation by pot-culture methods at Nyakato by Mr. C. Harvey. Such a deficiency is by no means improbable in these exhaustively weathered materials now well advanced into a

second or third cycle of eluvial decomposition; it can only be said that it has not manifested itself either in crops or in stock in any specifically recognizable manner.

Soil Amelioration

The experimental plots at Nyakato have been made to yield a full crop by means of organic compost, but the amounts needed have been very large. On my visit there I learned of dressings at the rate of 50 to 80 tons per acre. It is clear that to employ such quantities is quite beyond the resources of the private cultivator. Even if family groups combined to provide the labour, neither the large bulks of raw composting material nor the necessary amounts of cattle manure are to be had that would be required for applying the method on a sufficient scale on this basis. Is there then any practicable solution at present in sight of the problem of reclaiming these infertile lands?

In seeking the elements from which a solution may in time be pieced together, the following considerations, doubtless among others, deserve attention. (1) The people have spending power. (2) They are accustomed to buy slaughter stock from across the Lake. (3) They possess cattle which, by means yet to be worked out, can surely be increased in numbers and made to play a constructive part in the system of husbandry, especially through their manure. (4) Cotton seed is ginned annually in large quantities in parts of the lake basin not far distant, and much of it is potentially exportable from there to Bukoba.

It is essential to any solution that fertility in some form shall be imported from outside the region. It has been partly at the expense of the intervening common lands, now grasslands greatly impoverished, that the productiveness of the village banana groves has been built up. Over a long period in pre-European days, Peter has been robbed to pay Paul. The village sites, populated to capacity and now wishing to expand their limits, must expect to make repayments, and this they cannot do merely by a redistribution of surplus plant nutrients, e.g. by carting out manure; for as I have shown, the total internal stocks of mineral plant nutrients in the district were originally small, and in so far as they have been concentrated and conserved in the banana gardens they are fully engaged. There must be cash expenditure upon purchases from outside.

There are at least two channels in view through which extra-regional fertility can be introduced. One of them is already flowing freely but might perhaps be guided to be of greater benefit. There is an import of a heavy tonnage of manurial units in the form of slaughter cattle, but it is doubtful if much of it finds its way in real effectiveness to the land; certainly none is applied consciously and systematically to the purpose we are now considering, the reclamation of the barren lands. Of the imports of meat on the hoof Mr. W. E. H. Scupham, Provincial Commissioner, wrote as follows in 1935 [8]:—

> "The internal trade in cattle between the Sukuma district and Bukoba continues to increase and a vast number of slaughter cattle have been imported to satisfy the Bukoba coffee growers' increasing desire for meat. The trade is an economically sound one since, in effect, it enables the cattle-owners of Sukumaland to share in the proceeds of the Bukoba coffee trade."

The economics of this trade cannot, however, be regarded as really sound *unless at both ends of it the land from which the produce is won receives its due share of "the proceeds"*. I am not here

concerned with how the Sukuma cattle-owners spend their share of the coffee earnings of Bukoba, though in Usukuma also there are urgent problems of fertility maintenance that need analysis from this point of view amongst others. But at the Bukoba end it should be a matter of close concern to the tribal authorities that as much as possible of this large income of manurial value shall in one way or another be effectively applied to the land, not, I think, directly to the soil but to increasing the nutrient content of made compost and so reducing the amount of compost needed to make the grassland soil produce a crop.

That is one channel through which fertility can be brought in. Another that suggests itself is through the cattle of the Bahaya themselves. These cattle are the long-horned Ankole breed. In Musoma District on the east side of the Lake, in a country of much less humid climate and of soils of direct derivation from primary rocks, this breed is regarded as a reasonably economic one in its rate of growth and increase. The same is true of the Ankole breed in the drier parts of Bukoba District itself a little to the west. In easternmost Bukoba, however, the Ankole cattle are very slow in maturing; they breed only every other year; there is high mortality of calves from tick-borne East Coast fever; and the cattle population cannot be increased to the numbers the people would like to have even in the traditional aspect of cattle as *symbols* of wealth, while as real wealth in an economic sense the individual beast is practically valueless.

The desirability of increasing the numbers and quality of the cattle in Bukoba for the sake of derived effects has long been recognized. "It is considered that the construction of a much larger number of dipping tanks in the district would react on the condition of the coffee through the establishment of permanent herds of cattle." (*Annual Report of the Department of Agriculture,* 1931.) It seems clear however that the cattle population is limited as much by the very low nutritive value of the pasturage as by parasite-borne disease. If, simultaneously with the necessary measures in veterinary hygiene, the plane of nutrition could be raised, the problem would solve itself in an accelerating benign cycle. The district cannot at present feed its cattle better directly with grown produce; again it must buy from outside. The obvious source of the required supplementary feeding units, at least as regards protein and energy, is the seed ginned from the Mwanza cotton crop. For the purchase of this a portion of the coffee "proceeds" will have to be earmarked, instead of the whole cash income from coffee being regarded, as at present, purely as spending-money. The manurial value of the supplementary feed will in part be realized directly on the pasture if selected areas are paddocked, heavily enough stocked and grazed in rotation. The remainder of the manurial value will appear in the dung heap and hence in the compost yard; and so in due time it will be realized in the ability to obtain a crop by reasonable rates of application of compost, when the improved pasture is fit to be broken for cultivation.

It may be objected that this is too advanced a programme to be proposed to an African tribe now only in its second generation of experience of anything outside its ancient traditions. There is answer to this on several counts. The Bahaya have already shown themselves not altogether unresponsive to suggestion towards improved agricultural practices. The advances in their treatment of the coffee crop after picking, and in field

hygiene for pest control, during the last decade, are sufficient witness to this. There the suggested improvements appealed because of their obvious cash value. Cash is, however, still a novelty. Cattle are equally a currency amongst the people and are very near the tribal heart. Whereas direct exhortation to fertilize the outlying lands at the family expense for landless youth might well fall on deaf ears, a suggestion to increase the fertility of the cattle by a policy of high feeding should appeal to the cattle-owning elders, and would, if suitably followed up, have the same final effect in making more land available for crops. The effect at full value cannot in any case be expected quickly. It will be a matter of slow but accelerating accumulation of increments of fertility extending over a generation; and during that time the African cultivator, in a closely administered district such as this, will undoubtedly grow to an appreciation of the value of high-farming methods on their own merits.

ACKNOWLEDGMENTS

The material for this essay could not have been gathered without the assistance in various ways, especially in obtaining soil samples, that I have had from members of the Department of Agriculture, particularly from Messrs. A. H. Savile, C. Harvey and H. Gillman; from Mr. C. Gillman on geological matters, and from Mr. W. E. Calton at Amani in laboratory work.

SUMMARY

Soil conditions in the humid eastern part of Bukoba District, on the west side of Lake Victoria, are examined, first in the light of the natural factors in soil formation, which have led to laterisation and general poverty in plant nutrients, but with local inequalities due to the parent rocks; and secondly in the light of the effects of human occupation, which have been to accentuate the local inequalities, so that the environs of villages are productive but the inter-village lands are infertile.

The area of productive land can be increased only if the cash income from coffee is devoted in part to the importaton of plant nutrients from outside the district. Suggestions are made for giving effect to such a policy by organizing the better disposal of wastes from imported slaughter cattle, and by raising the plane of nutrition of the cattle kept locally.

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Root-knot Eelworm

By W. Victor Harris, *M.Sc., A.I.C.T.A., F.R.E.S., F.Z.S., Entomologist, Department of Agriculture, Tanganyika Territory*

The general unthriftyness, yellowing or sudden wilting of garden flowers such as balsams, of vegetables including tomatoes and parsley, and of a number of field crops are often attributed to drought, waterlogging or poor soil conditions. An examination of the roots of such plants will frequently show the presence of swellings or galls on the finer rootlets, while the main roots are distorted and perhaps gnarled and cracked (Fig. 1).

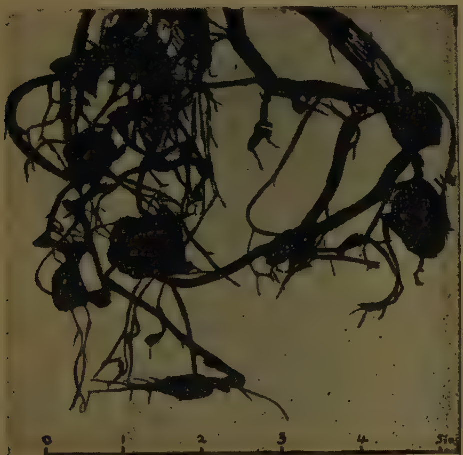

Fig. 1

Roots of *Plumbago zeylanica*, ornamental plant, showing root knots caused by the eelworm *Heterodera marioni*

The reason for this is that the root system has been invaded via the growing points of the rootlets, by minute eelworms or nematodes. The presence of these eelworms in the roots irritates the plant tissues to abnormal growth and the galls or root-knots develop. These abnormal cells split and die, giving the galls a characteristic gnarled appearance, and the surrounding tissue is discoloured. The fine sap-conducting tubes inside the rootlets become broken and incapable of taking up water from the soil. The energies of the plant are side-tracked into new root production to replace the losses caused by the eelworms, and the growth of the plant is interrupted. The result depends in the intensity of the attack and the initial vigour of the plant. The extra strain of flowering or fruiting may find the plant so far weakened that wilting and death results. Alternatively, the production of secondary rootlets may be sufficient to keep pace with the attack and so enable the plant to develop normally.

Life History

Eelworms are the smallest members of a group of the animal world known as Nematodes or Roundworms. They are far removed from such other worms as earthworms and tapeworms, though share with the latter an almost general parasitic mode of life. The larger nematodes, up to several feet in length, are parasitic in man and animals. Of the smaller forms, or eelworms, some are quite free living, others only invade diseased plant tissues as scavengers, while the remainder are definitely parasitic in habit.

The root-knot eelworm is called *Heterodera marioni* (*Heterodera radiciola* is an older name for the same animal). While generally distributed throughout the world, it is of greatest importance in the tropics and sub-tropics. The related *Heterodera schachtii* is the common root eelworm in the temperate zone, where it causes "potato sickness", sugar beet disease, etc., while *H. radiciola* is mainly a greenhouse pest there.

The young or larval eelworm hatches out from an egg in the soil. It can remain for months without food. It is also supposed to be able to move through the soil

in search of a host, and at least can be carried along by soil water movements. Arrived at an attractive rootlet, the larva works its way into the tissues at the growing point, comes to rest at a suitable spot and begins to feed and develop. If a female, and males are not so common, the larva swells as it grows, and on reaching maturity is a pear-shaped glistening white globule containing a large number of eggs. According to Goodey [1] from 300 to 600 eggs are laid by the average female, though as many as 1,200 have been recorded under particularly favourable conditions. Parthenogenetic reproduction is normal and regular, that is to say males are not necessary and are only produced under special conditions, usually those adverse to the eelworm. If the female is near the surface of the gall, the eggs are extruded into the broken-down cells in a gelatinous mass and so pass out into the soil. When this is impossible owing to the female being deep inside the tissues, the eggs may develop and hatch inside her and the larvae move out into fresh tissues without leaving the host. The eggs are oval and slightly bean-shaped. They are about 0.1 mm. in length (Goodey gives 0.067–0.128 mm. as the range). The young larvae are slender, about 0.5 mm. long. The mature females reach a size up to 1 mm. in length, and 0.75 mm. in diameter.

The optimum temperature for development is given by Tyler [6] as in the neighbourhood of 81° Fahrenheit, at which temperature an eelworm may grow from a free-living larva to an egg-laying female in sixteen days. A further week to ten days is required for the eggs to hatch out. At lower temperatures the development is progressively slower until at 58° the period of growth reaches eighty days and the eggs require from five to six weeks for hatching. Soil temperatures of 32° Fahr. will not necessarily kill all the larvae present, and at even lower temperatures eggs will survive. The ability of larvae to penetrate plant roots decreases rapidly with fall in temperature, and susceptible crops that will develop around 55° may be grown in infested soil. At a temperature of 110° all stages are killed in two hours, and at 135° death is instantaneous.

Soil moisture does not appear to have much influence on eelworms within the limits which are tolerated by plants. The larvae are more active under damp conditions, particularly under irrigation. But all stages are susceptible to actual drying out of the soil.

Reports regarding the influence of soil texture on eelworm attack are rather conflicting, but it would appear that in many instances light porous soils are more favourable for eelworms than the heavier clays.

Identification

Eelworm attack is indicated in woody plants by a cankerous growth at the collar immediately below soil level (Fig. 2) as well as by knots on the fine rootlets as described for softer plants (Fig. 3). Since collar troubles of a similar nature are caused also by fungi, bacteria and insects, and since, in the case of legumes especially, swellings on the rootlets may also arise from other causes not necessarily pathological, it is essential for careful examination to be made before blaming eelworms for the trouble. Furthermore, there are in all localities eelworms which do not attack plants but which may be found in the soil around the roots, and may in consequence be taken for root-knot eelworms under the microscope.

Plants for examination should be lifted carefully from the soil, breaking as few

rootlets as possible in the process. The adherent soil should then be washed off with water. If large root knots are found they may, on cutting open, show the glistening white globular females visible to the naked eyes or by the aid of a hand lens. In any case one of the root knots should be detached and teased out with needles in a drop of water on a glass slide and examined with a dissecting lens

Fig. 2
Effect of attack by *Heterodera marioni* on the collar of the mkweme or oyster nut, *Telfairea pedata*

or low power microscope. The pear-shaped females (Fig. 4c) are the most typical feature of the genus *Heterodera*, as in the other genera the females do not swell up in this manner. The nymphs of *Heterodera* are slender and taper slightly at the head, and rather more so to the tail (Fig. 4b). Long finely pointed tails and blunt heads are typical of the free living harmless soil inhabiting eelworms (Fig. 5), the presence of which bear, of course, no relation to root-knot eelworm damage. Numbers of eggs are usually found in eelworm galls, and, where the material under examination has been out of the ground for some time, are frequently the most noticeable indication of eelworm attack.

Fig. 3
Root knots on tobacco seedling infected with eelworm

Host Plants

A considerable number of plants have been recorded as hosts of the root-knot eelworm. A list published by the Imperial Bureau of Agricultural Parasitology [2] gives 569 hosts from all parts of the world, and these are continually being added to. Plants may be divided into three classes in accordance with their reactions to eelworm:—

1. *Susceptible*—plants on which eelworms thrive and whose health suffers in proportion to the number of eelworms present.

2. *Tolerant*—plants which support a moderate number of eelworms without showing any ill effects.

3. *Resistant*—plants which will not support eelworms.

Among the susceptible plants noted by the writer are the following:—

Mulberry	Tomato
Coffee	Parsley
Mkweme nut (*Telfairia pedata*)	Lentil
	Madagascar bean
Tobacco	Balsam

Plants observed to be tolerant to eelworms are:—

Turnip	Nasturtium
Cabbage	Cotton

The following are among those plants listed [7] as resistant to eelworms:—

Oats	Sorghum	Peach
Wheat	Sunn hemp	Gaillardia
Rice	Citrus	Zinnia

In case of soybeans, velvet beans, cowpeas, sweet potatoes and other plants, varietal resistance to root-knot eelworm has been discovered, and where such varieties can be developed by the plant breeder, the eelworm problem is considerably simplified.

On the whole, staple native food crops are little affected by the root-knot eelworm.

Weeds are to be found in all three groups. Grasses are mainly resistant, but broad-leaved weeds are to be regarded with suspicion.

Prevention

If land is free from *Heterodera marioni*, as indicated by the absence of root knots on plants such as tomatoes or balsam, every care should be taken to avoid

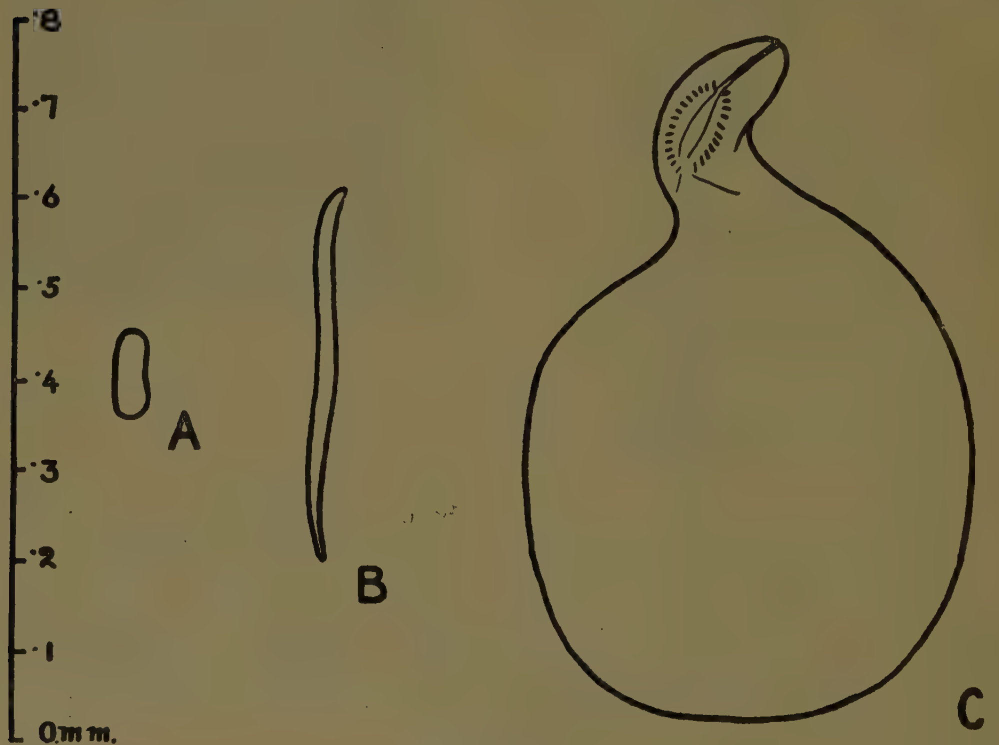

Fig. 4
The root-knot eelworm, *Heterodera marioni*
A. Egg. B. Larva. C. Mature female.

infection. A single larva will develop into a female laying many hundreds of eggs, and under our conditions a generation each month will soon result in an incredible number of descendants in the space of a year. Plants should only be introduced from eelworm-free nurseries. Seedbeds, nurseries and boxes of soil are frequently heavily infested, because of their being in continual use, kept moist

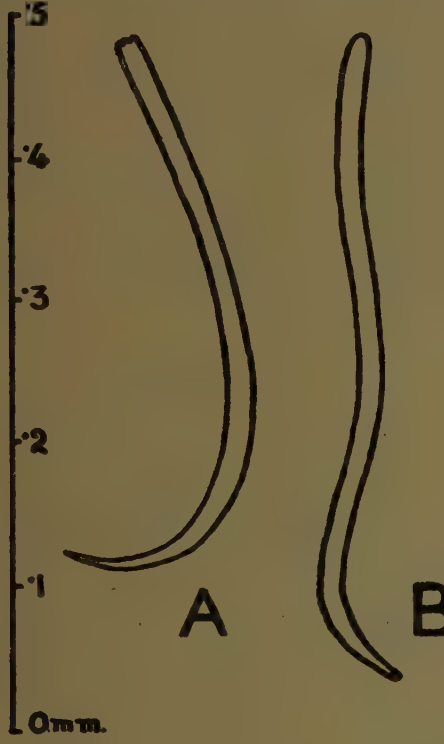

Fig. 5

Comparison of typical harmless soil inhabiting eelworm (A) with the injurious root-knot eelworm (B)

and warm, and supplied with attractive young plant material. In the case of orchard plants brought from a distance, it is always a wise precaution to wash away all the accompanying soil before planting out. Irrigation water is suspected as being a fruitful source of infestation, by washing out eelworms from infected land and carrying them to clean land lower down its course.

Cultural Control

Le Roux and Stofberg [5] carried out an investigation of the possibilities of cultural methods for controlling root-knot eelworm. Using tomatoes as indicator plants they tested the effects of the following treatments on an infested area of soil previously under tobacco:—

1. *Susceptible crops*—beans in winter, tobacco in summer, served as a check plot.

2. *Weeds*—all weeds were allowed to grow undisturbed; many weeds are eelworm host plants.

3. *Resistant crops*—oats in winter, sunn hemp in summer; these were chosen for the purpose of starving the eelworm by suppression of tolerant and susceptible weeds.

4. *Clean cultivation*—bare fallowing, with fortnightly hoeing of weeds to starve out the eelworms.

5. *Clean cultivation*—bare fallowing with monthly ploughing and subsequent weeding to kill off eelworms by starvation and desiccation.

Their results were as follows:—

1. *Susceptible crops*—subsequent infection of indicator severe.

2. *Weeds*—infection of indicators less than above but still high.

3. *Resistant crops*—infection of indicators light, showing fairly satisfactory results.

4. *Clean cultivation*—(hoeing)—good control, with only light infection of a small proportion of indicators.

5. *Clean cultivation* (ploughing and hoeing)—the most satisfactory control of all. None of the indicator plants grown in tins of soil from plot showed any sign of infection.

These results are in agreement with those obtained by American workers (Tyler and others). Dry fallowing cannot be expected to kill off all eelworms, but only to reduce their numbers to the extent of making crop production economic; a single treatment will not produce a permanent effect, but must be repeated at intervals, by being incorporated in the rotation.

Chemical Treatment

The present cost of chemical treatments of the soil to kill off eelworms prohibits their use on a field scale. They can be used in greenhouses, seedbeds, nurseries and for small areas of valuable crops in gardens. They are not suitable for use in orchards as they are injurious to growing crops. In a recent summary [3] the following effective methods are quoted:—

(*a*) *Formalin.*—A 1 per cent solution at the rate of 1 gallon per 50 cubic feet of soil effectively controlled eelworm and appeared to stimulate the growth of tomato seedlings from seed sown immediately after treatment.

(*b*) *Carbon bisulphide.*—Used in an emulsion of 68 per cent carbon bisulphide, 26 per cent water and 6 per cent rosin fish oil soap, diluted for use with water at the ratio of 1 to 50 and applied at the rate of 1 gallon per square foot. This gave a satisfactory control in greenhouse beds at a moderate cost. Direct application of carbon bisulphide is also effective, but more difficult to regulate than when used in an emulsion.

Heat Treatment

The partial sterilization of soil by heat is a regular practice in greenhouses. The use of steam apparatus is not practicable in the open. Much can be accomplished, however, by the careful utilization of brushwood and rubbish, to be burnt when preparing seedbeds. This is the usual practice for tobacco seedbeds, and though, as Jack [4] points out, it does not ensure eradication of the eelworms, neglect to burn the beds may lead to severe infestation. It is worth the trouble to burn over all seedbeds which cannot be prepared on new sites, whether for permanent crops like coffee, or for annuals such as vegetables and garden flowers.

Summary

The root-knot eelworm, *Heterodera marioni,* is a widely distributed plant pest causing wilting, general debility, collar rots, etc. The life history is described, together with notes on its identification.

A large number of plants are susceptible to eelworms, but others tolerant or resistant.

The importance of keeping uninfected land free from eelworm is stressed. Cultural methods to keep down the numbers of eelworms in infected land and allow susceptible crops to be grown are indicated, particularly the inclusion of a bare fallow in the rotation. Chemical methods are noted.

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Sterility

PRELIMINARY DESCRIPTION OF A FORM OF STERILITY IN CATTLE ASSOCIATED WITH VAGINITIS IN FEMALE STOCK AND WITH CHRONIC CHANGES IN THE EPIDIDYMIS AND IN THE TESTICLES OF BULLS

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INTRODUCTION

The first cases of this disease were seen in Kenya about 1928, and since that date it has been recognized on many European farms throughout the settled areas. The disease occurs in pure-bred bulls of almost all the European breeds, and in both high- and low-grade bulls. The Masai apparently know the condition, and refer to it by the same name as that used by them for gonorrhoea in man.

The available evidence suggests that the disease is transmitted by coitus, and that it has spread from farm to farm by the introduction of bulls or female stock, or by sending a cow over to a neighbour's bull for service. The importance of the condition to stockowners may be gathered from the results obtained in examining bulls for fertility on European farms. During the last two years 250 bulls have been examined and their relative fertility is given in Table I.

TABLE 1

	Number	Percentage
High Fertility ..	86	34·4
Reduced Fertility ..	32	12·8
"Temporarily Sterile"	25	10·0
Sterile	105	42·0
	248	
Clinical Examination Only	2	(No epididymitis)
TOTAL ..	250	

It will be observed that the percentage of bulls found to be sterile is very high. Table II classifies the causes of sterility in the 105 animals.

TABLE 2

Cause of Sterility	Number of Bulls	Number Incapable of Service
Epididymitis ..	78	26
Testis Abnormal ..	10	5
Penis Abnormal ..	3	3
Sperm Absent ..	6	—
Sperm Poor ..	8	—
TOTAL ..	105	34

Service could not be obtained from 59 of the bulls examined. Of these 34 are included in Table II. The remaining 25 showed no clinical abnormalities and are included in Table I as "Temporarily Sterile".

The condition described in this paper was probably responsible for all the cases of epididymitis in Table II. Bulls were examined on thirty-three different farms and cases of epididymitis were found on twenty-one.

DESCRIPTION OF THE CONDITION

Many of the early outbreaks of the disease occurred in ranched herds. Cows were run with the bull, and no breeding records were kept. The history reported was that the owner had had no calves for several weeks, and that, so far as he could see, none of his cows were in-calf. In some more recent outbreaks, records

have been available, and it has been found that the female stock return at irregular intervals. Some appear to hold to the first service for a period of three to five months, after which they come on heat and, in spite of service, return regularly to the bull at three-weekly periods.

Examination of a herd always reveals the presence of vaginitis. In severe cases, the vagina is red, its mucous membrane shows patches of small raised nodules, and along its floor trickles a slimy yellowish discharge. Many cases can be picked out by the dried discharge adhering to the hairs of the tail, on a level with the lower angle of the vulva. In less severe cases, evidence of infection is restricted to the presence of a small, rough patch of orange nodules. Examination of maiden heifers and heifer calves shows that they also suffer from a form of vaginitis, usually only of the mild, orange-nodule type. If any discharge is present it is small in quantity, and almost white in colour. This latter type of vaginitis can be demonstrated in the great majority of herds of cattle in this country whether they suffer from breeding troubles or not. In consequence of this, during the early stages of our investigations, we were led to believe that the outbreaks of herd sterility were in the main due to the bull. There is no doubt that on many of the affected farms, even under normal conditions, the number of bulls was insufficient, and, of course, the frequent returnings to the bull greatly increased the degree of overwork.

We always recommended that new bulls be introduced, and what almost invariably happened was that the new bulls for a time stopped the majority of cows that they served, but after a period they ceased to be of use and further new bulls became necessary. This state of affairs usually continued for eighteen months to two years, when many of the cows and heifers began to breed again. Between 5 per cent and 20 per cent of them, however, always remained permanently sterile.

The subsequent history of these herds has been, that in spite of the persistence of a certain amount of chronic vaginitis, the remaining cows have bred. Young heifers, as they have come on, may have shown more acute vaginitis, and have been difficult to get in-calf.

Sterile bulls from affected herds constantly show typical lesions, which to the best of our knowledge, have not been described from other parts of the world. In many, a general swelling of the testicles has been reported. This recedes, but leaves an enlargement of the head or tail of the epididymis, and sometimes of the adjacent parts of the testicle. The enlargement is hard and varies in size, up to that of a cricket ball. Frequently, it can be seen when standing behind the animal, and it can always be detected during life by palpation. Instead of being

Photograph showing on the left a normal testicle and on the right a testicle with the epididymis enlarged and indurated

loose in the scrotum, the testicles are often closely adherent to the inner lining of the sac. On post-mortem examination, the ducts from the testicles may be found occluded and the vesiculae seminales are shrunken and hard. Lesions in the bull

are often very marked before any diminution in sexual appetite is noticed. Thus, a bull may be completely sterile for several months before he is suspected of being impotent. Eventually, many of the affected bulls lose all desire to serve.

Post-mortem examination of the permanently sterile female stock reveals lesions which can easily be seen to account for the sterility. The Fallopian tubes through which the egg passes from the ovary to the uterus are blocked. Sometimes they are blocked in several places, and the secretion of the normal mucous fluid of the cells lining the tubes causes cysts to develop. The funnel-shaped end of the tube which receives the egg when it leaves the ovary may be adherent to the ovary and the continued secretion of fluid may have formed a cyst. In other cases, where a cyst has obviously been present but has ruptured, the egg, on extrusion, drops into the abdominal cavity.

In both cows and bulls, a dry, adhesive peritonitis may be present. The liver may be firmly adherent to the diaphragm on the one side and to the stomach on the other.

More recently, it has been possible to examine a number of acutely infected females with a satisfactory vaginal speculum. This has revealed that the vaginitis in typical cases is much more severe in the anterior third of the vagina than nearer the vulva. The most advanced lesions are usually situated near the os. The os itself is very congested and the yellow slimy discharge must in part originate from inside the cervix. This is what one would expect, for if permanent changes can be produced as high up as the pavilion and Fallopian tubes, it is obvious that invasion of tissues higher up than the vagina must occur in some cases, if not in all.

Lesions of the sheath and penis in bulls are not often seen. As in the female, however, in a percentage of cases, infection spreads up the genital tract giving rise to the chronic lesions already described.

Experimental Work

It is not proposed to describe the large amount of experimental work that has been carried out at Kabete and at the Experimental Station at Naivasha. While a new series of experiments at the former place appears to be giving more promising results, all our efforts have so far failed to elucidate the cause of the condition. In part, this has been due to the fact that the majority of animals received for experiment have been bulls and cows that have been permanently sterile for several months. The fact that a form of vaginitis occurs in herds that have always had good breeding records has also caused confusion. The evidence now available suggests very strongly that two types of vaginitis are present in Kenya. One, usually a mild condition, occurs frequently in heifers that have never been to the bull, and even in young calves, as well as in breeding females. The other, much more serious, appears to be spread by coitus. Once it is introduced, it leads to a general herd sterility. Whether an animal, male or female, becomes permanently sterile depends on whether infection spreads up the genital tract or whether it remains localized in the vagina of the female or sheath and penis of the bull.

The experiments on artificial insemination, which were begun at Naivasha in 1935, have introduced a new method of studying the disease, and have thrown some further light on the condition. Examination of the semen is a normal part of the procedure, and it was not until this work was started that we

realized the enormous proportion of infertile bulls in the herds in Kenya.

Apart from the better known advantages of artificial insemination over the normal method, the fact that it enables the stockman to watch the fertility of his bulls is of very great importance.

Methods of Control

The vaginitis in female stock should, of course, be treated. The sooner treatment is begun the better, for it is possible that early treatment may prevent spread of infection to the anterior parts of the genital tract. Experience has shown that, to be effective, treatment must be repeated at frequent intervals and that it is advantageous to use some device that liberates an antiseptic over a period rather than to inject an antiseptic solution. Certain types of pessary appear to be satisfactory and good results have been obtained with proprietary preparations consisting of papers impregnated with antiseptics. As the severe lesions are situated in the anterior third of the vagina, care should be taken that the antiseptic reaches this part of the genital tract.

Once a bull shows definite lesions in the epididymis, treatment is of no avail. The ideal method of preventing infection in the bull is to inseminate all female stock artificially. In addition artificial insemination ensures a satisfactory control of the fertility of the bull, minimizes the risk of spreading infection among cows and heifers and, by allowing of the introduction of semen direct into the uterus of an animal already affected with the disease, it gives a reasonable chance of conception if the infection is restricted to the vagina. In the absence of apparatus for artificial insemination care should be taken that the bull is not allowed to serve any cow showing a vaginal discharge. As an additional precaution the sheath of the bull may be irrigated with a suitable antiseptic solution after every service.

Some Observations on the Pruning of Single Stem Coffee

By G. D. SECCOMBE; *Kiama Ltd., Thika, Kenya Colony*

The bringing of coffee-growing to a successful issue depends on three main factors, which are:—

(1) Climate, including rainfall and its seasonal distribution, altitude, and range of temperature.

(2) Soil, including manuring and soil treatment.

(3) Pruning, either single stem or multiple stem system.

The meteorologist may claim that of these (1) is the most important; the soil expert (2); but we hope to show in the following remarks that (3) is equally, if not the most, important.

With the coffee-growing districts of this Colony having an altitude variation of anything up to 2,000 feet, a vast range of average rainfall, and a soil varying from a sandy pink through the ideal chocolate loam to black cotton, and with such an inconsistent and contradictory crop as coffee, it is obviously impossible to lay down any hard and fast rules on such a controversial subject as pruning. Having this view in mind the opinions here expressed are only intended to be general and are obviously open to criticism, but they are the opinions formed by the writer from personal observation, and are not from pooling the opinions expressed by other planters.

For the sake of clarity we will divide our subject up into three divisions, namely: (*a*) why we prune; (*b*) when to prune; (*c*) general remarks.

(*a*) *Why we prune*.—The highest single tree seen by the writer in this Colony was somewhere in the neighbourhood of 20 feet; without going into details, this is clearly an uneconomical way of growing coffee, so we prune to keep our trees or bushes within normal bounds. One might make a very rough and ready rule by saying "the drier the area the smaller the tree" without going very far wrong, to which might be added "and the fewer the number of trees per acre". But what about covering the ground? Why should one cover the ground? Because in the hotter, drier districts it is important to conserve soil moisture, much of which would otherwise be lost by evaporation. The ground can cover itself, however, either by judicious cultivation or by box-ridging and kindred methods.

We also prune to remove old wood that has already borne fruit, thus leaving a nice open tree to grow fresh bearing wood; we consider this most important and it is probably the reason for the success obtained by multiple stem trees under a different treatment. We also prune to control crop once it has formed; if more of this had been done during the past four years of drought there would not have been such a big market in *buni*, nor would there be the many crippled trees seen on some plantations.

A large number of trees seem to have too many primaries on them, excepting, of course, those which have had them knocked off by ox cultivation. Going through plantations in some areas, trees are often seen with the primaries dangling about like seaweed on a half-tide rock; a glance will show that the tree is carrying far too many primaries and a closer inspection will reveal many simply crying to be cut off. In this Thika area for instance, twenty primaries are, in our opinion, ample and sixteen not too few. We know of one tree with only six primaries that has averaged two gallons for the past seven years and always looks well.

Finally, we prune to remove surplus secondaries and tertiaries so that the remainder may enjoy a strong and vigorous growth, thus producing, I think, bold coffee.

(*b*) *When to prune*.—Young coffee, till it has borne about three crops, requires very little done to it bar keeping off suckers, when, if it has not suffered from mealy bug, antestia, or other pests, it is likely to be getting a bit too much spread out and should be cut back a little. One often sees on young coffee, and old too for that matter, long thin wire-like secondaries reaching out anything up to four feet or more with nothing on them but a few leaves at their tips. These seem to have a more detrimental effect on the tree than a month's drought and the way the tree recovers after they have been cut off is very marked.

For fully grown coffee, after a heavy crop has been carried in droughty conditions and the trees are suffering from it, nothing is gained by being in too much of a hurry to get the knife going, in fact the reverse is true and a great deal of harm can be done by pruning too soon. The trees should be allowed to recover normally first.

As regards routine pruning, if the trees are in condition the heavy work is usually done as soon as possible after the main crop is off. In the area where the writer lives, picking is finished by the end of December; any crop left is stripped, and pruning starts immediately so that it is completed by the end of February. The pruning period, must, of course, vary according to the district.

In some years there would appear to be one exact week when the pruning should be done. Unfortunately it is not possible to do it all in the time; instead, the pruning is frequently spread over three months or more, which cannot be right.

As a general rule, if the bearing wood is not in condition by Christmas, it will not do much flowering during the March-April rains, and the same interval applies to those flowering in the short rains. Exceptional climatic conditions would upset this general principle, as indeed happened in one case we know of last year, when a plantation which should have flowered during the short rains of 1935 failed to do so owing to drought. It was cut back fairly heavily in the last fortnight of December and getting much unseasonal rain and warm weather, it made a new wood and was flowering by April 1936 and carried a good crop.

After a sufficient interval, say three to four months, has elapsed since the main pruning to allow of a nice strong growth being established on the trees, we arrive at the time to do what it is the custom of the country to call "handling" and a more brutal term it would be difficult to imagine, though it aptly describes what only too frequently happens. A pruner seizes hold of the end of a primary, rips off all the beautiful new growth, like plucking out the wing feathers of a tough goose, leaving a miserable tassel at the end; the whole sad affair more resembling a cow's tail than the primary of a coffee tree. A coffee planter of repute once asked us if we were going to give our pruners knives to do the "handling" with! We can only state that, with the exception of a few baby shoots, all our "handling" is done with knives, and should a boy be discovered resorting to the above-mentioned process of plucking, there is trouble for somebody. Nobody likes to have a hail-storm on their coffee, yet the same result can be obtained by plucking off growth with its attendant

inch of bark when handling, and paying for it at that. At the handling period, if ever, the utmost care is needed in selecting the right, and proper amount of, wood which is to be the foundation for the next season's crop. It is not just a simple matter of "tops, bottoms, and centres".

In the lower and warmer altitudes, where growth is very rapid, handling should not be commenced too soon, as doing so rather encourages the wood left on the tree to run away and get too whippy before maturing. The converse is probably the case for the higher altitudes. Incidentally there is nothing like a crop on the tree to keep it within self-respecting bounds. If trees are bearing anything like a decent crop it will probably be found that one pruning and one handling will suffice for the year. However, this cannot be laid down as a general rule because it is sometimes the case with a light or no crop, and given favourable weather trees will make a quick and heavy growth after a fairly severe handling.

To deal with this is one of the most awkward affairs in the yearly programme as picking is generally going on at the time and no labour is available to handle the tree again, though they certainly ought to be. It is difficult to say when this ought to be done owing to weather conditions, sunshine, etc., but for a rough guide one might say from three to four months after the last handling.

(*c*) *General Remarks.*—As regards various systems of pruning. Some people believe in "parrot perching" or sticking. We cannot see anything to recommend it. To hack back the primaries in such a drastic fashion is to deprive the tree of its main foundation for growing crop-bearing wood. In adverse weather, secondaries are more liable to die back than primaries and, if this happens to a large extent, the results will be disastrous. Also, for some reason difficult to explain, it is very conducive to the development of gormandizers.

Then there is the method of capping young trees, the idea being to get a sturdy foundation on the tree before going any higher. It is claimed that this method prevents a narrow-waisted tree in later life caused by the middle primaries dying from over-cropping, etc. So it does, but the same conditions will cause the loss of the top storey of the capped tree.

Some planters are not content with capping once, but cap two or three times; our own opinion is, however, that each place the tree is capped causes a check in the sap flow.

Some planters adopt the methods of a senior wrangler, and reduce the art of pruning to an exact science. If there are so many tertiaries, so many secondaries, so many primaries per tree, the number of berries per tree will be so many and tonnage per acre so much. Very nice, so there may be, but our mathematics have never advanced beyond the nursery stage and have not yet succeeded in making two and two make five. It is only *le bon Dieu* who knows what the crop is going to be until it is actually hulled and bagged.

There is an old English saying that "no farmer should hoe his own roots" as he is prone to leave far too many. By the same token no owner should prune his own coffee. When pruning it is very easy to suffer from one of two vices, greed or parsimony. Greed by leaving too much bearing-wood on and so causing over-bearing; parsimony by not cutting enough crop off to ensure a decent crop for the coming season.

We confidently believe that the mediocre results given by some first class

plantations are due not so much to bad pruning *qua* pruning, as to incorrect pruning. The old adage "a bird in the hand is worth two in the bush" is not borne out in coffee growing. Instead of limping along on 2 cwt. or 3 cwt. per year as many do, it is far better to be drastic and get the bush into condition to yield 10 cwt. a year, even if this involves completely losing the first year's crop of 2 cwt. or 3 cwt. The loss of this crop will be well repaid by the increased yields of succeeding years.

When faced with that very difficult problem, and we are all faced with it at times, of making up one's mind as to what to do with indivdual plantations, we have always found it paid to err slightly on the drastic side rather than on the lenient. Half-hearted measures never serve with pruning.

Coffee should be grown for both pleasure and profit. Pleasure is put first on purpose for if there is no pleasure in growing coffee, so that one's heart is not in one's job, the chances are very slim of there being much profit. Coffee requires constant supervision from the day the tree is planted until the bean is in the sack and going down to the coast, and in no department is this more necessary than in pruning.

We believe that every planter knows how to prune or can learn with little trouble. The difficulty is to get our pruners to prune exactly as we want them to, and the only way to do this is by constant supervision. If you have a hundred pruners doing forty trees a day each, that totals four thousand trees daily, and if you are going to inspect the lot it will make quite a hole in your day's work. But it will be well worth it, for, apart from the profit, think of the exhilaration, and solid pleasure to be experienced walking along the rows behind the pruners on a crisp morning towards the end of June and gazing on the nicely handled trees, with their primaries standing well up carrying their season's crop, and the new growth coming on behind to be cut back too, for the next season's crop.

Let us remember that one of the finest coffees produced in the world is Kenya bold "A", the production of which should be the ideal at which we all aim, and the achievement of which, to a very great extent, can be helped on by the intelligent pruning of our single-stem coffee trees.

The Yield of Ghee

The following note was written by Dr. M. H. French, the author of the article on the Musoma Ghee Industry, in the January, 1938, number of this Journal, in reply to an inquiry from a correspondent as to the amount of ghee to be expected from 1 gallon of cream of 42 per cent fat content:—

"Theoretically 4.2 lb. of ghee should be obtained. Practically, of course, there is a certain loss in the process, but a yield below 4 lb. of ghee should be checked carefully. Lower yields are nearly always due to incomplete boiling or to not squeezing out the curd. Unless the temperature of the boiling liquid reaches about 250-260°F. the particles of curd remain bulky and contain much fat. At about this temperature the particles of the curd contract in volume and so are able to retain only a smaller quantity of fat."

A Note on Horses in the Eastern Province of Uganda

By M. G. DE COURCY-IRELAND, *B.A., Agricultural Officer, Department of Agriculture, Uganda Protectorate*

For years it has been understood that horses could not be kept in most parts of Eastern Uganda. It was known that one or two horses had been in Teso and Bugishu Districts, but rumour declared that they had died or had proved unsatisfactory.

In 1935, the writer decided to import a Somali pony into Teso District as he and several enthusiasts considered that horses could be kept. This pony was inoculated against Horse Sickness prior to her leaving Kenya. Beyond suffering from cracked heels and girth galls she has had no sickness whatever. As a result of this success it was not long before several Kenya progeny and country bred ponies were introduced, which have all done well in the short period they have been here.

As with all animals, and especially with horses, correct management is of vital importance. This does not appear to be as difficult as in some climates. Some sort of stable must be provided but it need not be of an expensive type. Low cost and a building as cool and hygienic as possible is the aim of most owners. A well constructed native hut makes a good loose box, provided it has a wide door of sufficient height and a well rammed murram floor. The walls should not reach the roof by at least one foot, so that the building may be airy without being draughty. If such a building can be erected under the shade of a large tree, the stable is always cool and dark enough to reduce fly trouble to a minimum. This type of stable is not ideal but it is cheap and has been found to answer well. Whatever type of stable is built, it should have a good thatched roof; it is the coolest form of roofing.

Dry *Lusenke* (*Imperata cylindrica*) and *Hyparrhenia* grasses form the most satisfactory bedding. A thick floor covering, daily attention and a weekly application of a strong disinfectant helps in keeping a stable sanitary and mitigates the risk of flies breeding on a damp floor. To maintain a dry stable with a murram floor a slope is essential as the horses are in at night and for the greater part of the day; if there is not some drainage the floor soon becomes soft and foul.

A "manger" should be placed on the floor and removed when not in use. Plenty of clean water in a fixed bucket should always be kept in the stable.

Feeding is not a great difficulty. Maize can be grown or bought very cheaply from Kenya, as can also barley, bran and oats. The latter are often of very poor quality and are not worth the cost. Care must be taken not to feed too much barley or maize with bran; it is thought that these heating foods may be the cause of the cracked heels from which some horses suffer. Hay and chaff at present are obtainable only from Kenya. Corn and bran with cut grass, such as young Elephant grass (*Pennisetum purpureum*) or young sugar cane, are found to be as satisfactory as, if not better than, chaff. At night a good bundle of these grasses and others such as *Chloris gayana* do well for racking down.

Except during a very dry season good grazing is plentiful in most parts of the Eastern Provinces. *Cynodon dactylon, Chloris gayana, Panicum maximum,* most of the *Hyparrhenia* spp. and many others make good feeding grasses. In some

places it might be advisable to grow plots of Elephant grass and sugar cane to carry over the dry season.

Horse Sickness is feared more than any other disease outside the "fly" infected areas. Periodical inoculations, as recommended by the Veterinary Department, and housing at night has been found, as in Kenya, to minimize this risk.

When grooming, all ticks must be removed. Cattle ticks have caused some horses great suffering through the syces not removing them from between their hind legs. In districts where this parasite is numerous a protection is to wipe the legs with a rag moistened with a disinfectant and oil.

Cracked heels are causing much concern to a few horse owners. The cause has not yet been diagnosed but it is possible that it is the result of excessive dryness, or bad stable management, owing to inexperienced syces. Thorough drying of the heels and an application of some oil is recommended.

The maggots of *Cordylobia anthropophaga*, the "tumbu fly", must be guarded against. These maggots if squeezed out before they are mature leave sores which very soon become fly infected. It is best to leave the maggot to drop or squeeze it out when ripe; the hole then readily heals. The chief places attacked by this maggot are the soft skin of the udder and between the legs. The fly lays her eggs in the bedding or on the stable floor; thorough disinfection is therefore important.

At present it is difficult to obtain good syces. Natives can be found who are handy with cattle and they can be trained.

So far the horses that have been imported into the Eastern Provinces are the type that are useful for hacking on *safari* and round the stations, but it is hoped that we may soon see our dreams of polo materialize, as the first meeting of the Eastern Province Pony Club has already been held.

Providing for the Safe Discharge of Flood Waters at Anti-Soil-Erosion Works*

By E. A. OOSTHUIZEN, *Engineer, Grootfontein School of Agriculture, Middleburg, C.P.*

In order to take proper care of the high flood waters from a catchment area and to ensure the safety of anti-soil-erosion works, adequate spillway provision must be made. It is therefore very necessary before the lay-out of such work is seriously considered that the approximate maximum discharge which may be expected in times of high flood, should be determined.

It is a fact that the general lay-out and design of training works depend almost entirely upon the amount of water to which such works will ultimately be subjected.

Take, for example, the case where the main flow of flood water is kept in the original channel by allowing it to spill over a central silt trap, while a controllable quantity of water is to be distributed over the veld by means of a system of training and contour banks. (See "Training Banks for Diverting Flood Waters", in the March 1936 issue of *Farming in South Africa.*)

The principle to be followed here is that of shallow flow, and not only should the spillway be designed so as to accommodate the high flood waters with the smallest possible depth of flow and therefore always allowing a controllable quantity of water for distribution, but the training and contour banks must also be designed for the quantity of water to which they will be subjected.

Take, again, the narrow deep sloot where it may not be possible or may not be desirable to take water out on to the veld, but where it is nevertheless necessary to check side erosion and undercutting of the banks and to prevent the sloot from scouring deeper. Here the flow is arrested at intervals along the sloot by means of light concrete silt traps, especially designed for the purpose, and provision has to be made for the whole of the maximum flow to pass safely through a narrow and deep spillway.

It has previously been mentioned that the depth of flow in a spillway depends upon the width of the spillway, and it should be emphasized that the width and the depth of a spillway play a very important part and often form the deciding factors in the design to be adopted.

For instance, it may be cheaper to raise an earthen embankment another 2 feet than to excavate another 50 feet of spillway, or it may be less expensive to increase the length of a masonry weir by, say 30 feet than to raise the wing walls and adjoining earthwork another 3 feet.

When once the approximate maximum discharge from a catchment area has been determined, it is a relatively simple matter to compute the width and depth of the required spillway.

EXPLANATION OF TERMS

Generally speaking, it is desirable to keep the depth of flow in a spillway as shallow as possible, and to ensure the safety of the works by allowing ample "freeboard". In order to understand the term "freeboard", it is necessary first to explain the terms "Spillway Level" and "High Flood Level".

*Reprinted from *Farming in South Africa,* XII, February, 1937.

Spillway Level, Fig. 1, is what is known as "Full Supply Level" in the case of a dam, i.e. the water level when the dam is full and just ready to overflow at the spillway, or "Full Silt Level" in the case of a silt trap.

"High Flood Level" is the level reached by high flood waters, and H, the difference in elevation between "High Flood Level" and "Full Supply Level", is the depth of flow in the spillway.

"wing" of a masonry weir, i.e. where the earthwork joins the masonry, is the weak spot of the structure, and in no circumstances should flood waters be allowed to reach the top of the staunching walls or the crest of the earth flanks.

DESIGN

In designing spillways, it is necessary to bear in mind that the estimated discharge from any natural catchment area

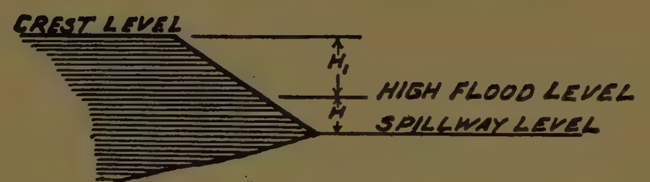


Fig. 1.

The "Freeboard" H_1 is the difference in elevation between crest level of the spillway flank or wing, as it is sometimes called, and "High Flood Level", and is of the utmost importance in the design of Training Works, as it is really the factor of safety as far as height is concerned.

The amount of freeboard to be allowed depends on local conditions and circumstances; for instance, in the case of a storage dam or of a weir with earth flanks, where an extensive impounding area may be developed in times of high flood, and where such area lies in the direct throw of prevailing winds, high waves may result and sufficient freeboard should be allowed to prevent waves from lashing over the top of the embankment or the flanks, assuming, of course, that an adequate spillway is provided.

Then again there is settlement and weathering to be allowed for in the case of an earthen embankment, and it should be remembered that the "shoulder" or

is a rough approximation, and should be regarded as such and used as a guide only, even though the special conditions of the catchment and the intensity of heavy rainfall have been carefully considered and taken into account as far as possible.

It is therefore essential that additional freeboard be allowed over and above that which takes care of the wave action in times of high flood, in accordance with the importance of the work.

The two common types of spillway met with in soil-erosion work are the spill-way channel which is usually excavated at one end of the earth bank forming a dam or training bank, and the masonry silt trap.

It is not the writer's intention to discuss in this article the structural details of spillways, but merely to show how the design for an adequate spillway can be easily effected without having to perform laborious calculations.

On the accompanying graph the width of the spillway and the corresponding depth of flow may be conveniently taken out for discharges up to 20,000 cusecs, and although the figures obtained from the graph are really suited to spillway channels, they may be applied to broad-crested weirs without appreciable error.

Examples

(1) A weir is to be constructed on a spruit whose width at the proposed site is 200 feet. Determine the height of the wing walls above spillway level if the freeboard is to be 5 feet and the maximum discharge is estimated at 6,800 cusecs.

Follow the dotted lines on the graph. The horizontal line representing 6,800 cusecs (680 x 10) is cut by the vertical line representing 200-feet (20 x 10) width of spillway at the 5-feet depth line. Hence the high flood level is 5 feet above spillway level, and the height of the wing walls is consequently 10 feet above spillway level.

(2) Fig. 2 shows the profile at the spillway end of an embankment. If the spillway level is to be at peg 20 and the estimated maximum discharge from the catchment is 2,000 cusecs, design the spillway so that the depth of flow is 2½ feet with a freeboard of 4 feet.

On the graph, the horizontal line representing 2,000 cusecs (200 x 10) is cut by the 2.5-feet depth line at the 165-feet (16.5 x 10) width of spillway line. The design is shown in Fig. 3. It will be observed that, in order to effect an economical design, the first 113 feet of spillway will consist of a low masonry wall, founded on rock, while the rest of the required width, i.e. 52 feet, will be excavated.

In considering the possibilities of a spillway site, it should be remembered

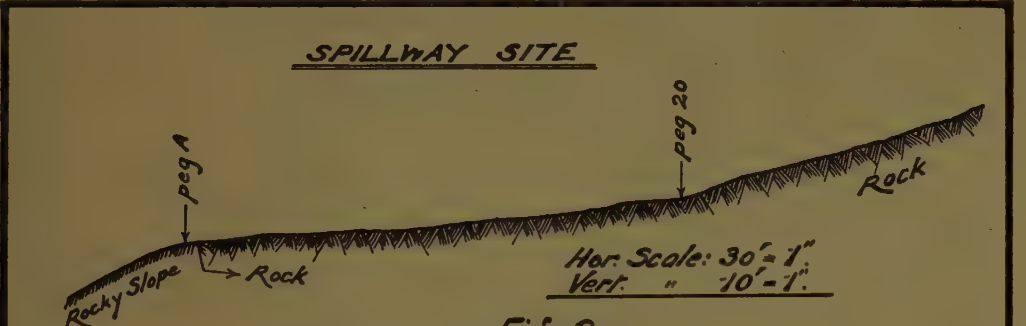


Fig. 2.

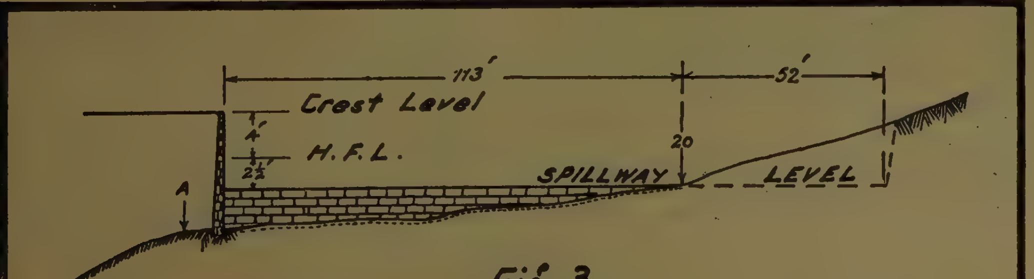
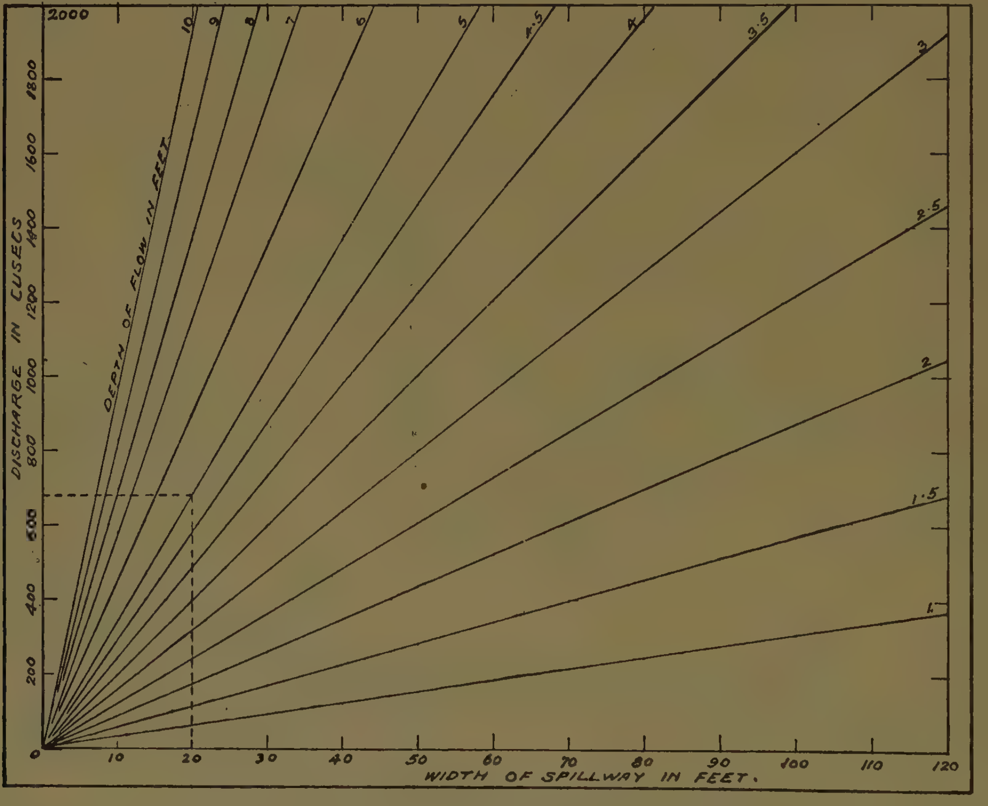


Fig. 3.

that, although the intensity of a flood is of such great consequence as far as the super-structure is concerned, the duration of the flood should also receive consideration in connexion with the foundation of the spillway wall or weir and the tail channel. The maximum discharge from a small catchment is usually the result of heavy rainfall over its entire area, but as heavy showers are mostly local and hardly ever last very long, the maximum flood is of short duration and the spillway channel does not suffer prolonged scouring.

In the case of a large catchment, however, it is the softer and more lasting rains which fall over the entire area that are responsible for the maximum floods, and this, together with the fact that the water has to travel a considerable distance, makes the period of maximum flood much longer than in the case of a small catchment, and consequently excessive erosion may be caused in the tail channel.



Graph for determining width of spillways and depth of flow

In selecting the spillway site, therefore, the period of maximum flow should be borne in mind, and the necessary steps should be taken in the design to protect the foundations not only against shock but also against "back eating" in the tail channel or "retrogression of levels".

Tea "Manuring"*

A TEN YEARS' RETROSPECT

By T. EDEN, *B.Sc., A.I.C., Agricultural Chemist, The Tea Research Institute of Ceylon*

One of the first matters to which I turned my attention ten years ago was the compilation of a recipe book of manures, to include every formula I could lay my hands on. In the near future, I should be called on to advise on manuring and to work out a scheme for experimentation, and I was seeking a datum line from which to work. I soon found that there appeared to be few, if any, guiding principles, on the quantitative side, that welded together into an intelligent whole the immense variety of prescriptions in vogue. It would hardly be an exaggeration to say that any combination of amounts from 10 to 40 lb. per acre for all the three standard nutrients, if picked at random out of a hat, would have been found to correspond closely to examples in actual use.

Looking through the published literature at that time and through the original correspondence files of my department, I find that the following were some of the statements and arguments on which manurial prescriptions were presumed to be based:—

(1) Nitrogen was necessary for plant growth, but not too much, or quality would be impaired.

(2) A considerable proportion of the nitrogen should be in the form of "organic" manures such as blood, oil cakes or fish offals, which, by reasons of slower availability would last longer, cause no rush of crop, and not impair quality. Such precautions as these might be relaxed in pruning mixtures because rapid growth was desirable in tea recovering from pruning and quality was no consideration in tipping leaf.

(3) By having a number of constituents providing nitrogen, all with varying availability, the latter could be put onto the basis of a relay race and ensure even growth.

(4) Potash was sometimes held to be unnecessary in manures because of the adequacy of soil supplies; it was sometimes given in substantial doses as an aid to wood growth.

(5) Phosphoric acid has been suggested as a factor in quality, but its chief function according to the ideas of the time was to stimulate root development. About this time it became prominent in pruning mixtures in quantities from 50 to 70 pounds per acre, and in the Institute files is an example of a pruning mixture containing no less than 300 lb. of concentrated superphosphate or 126 lb. of phosphoric acid per acre.

(6) Pruning mixtures were distributed and forked in as soon after pruning as possible to ensure rapid recovery and healing of the pruned cuts. For this reason although the distinguishing feature of pruning mixtures was high phosphoric acid, nitrogen was also added.

(7) Pruning mixtures and general mixtures were generally different in both ratio and constituents, and when a general mixture was given twice in a cycle there was frequently some difference between the constituents of the two dressings.

(8) There was a vague fear lurking in people's minds that acidity would be promoted by certain artificial manures and that this acidity, as in the case of temperate crops, would be detrimental. Basic manures such as Basic-slag were in moderate use.

If time permitted I could substantiate these items over and over again from my files, but I must merely ask you to use your own recollection and will content myself by giving two examples out of

*Reprinted from *The Tea Quarterly*, X, pp. 167-174.

many. In a *Tropical Agriculturist* article in June, 1931, the following statement occurs:—

> "One method of reducing cost is to substitute cheap inorganic nitrogen for more expensive forms, but it must be remembered that inorganic nitrogen, while it gives a rise in crop over a short period, tends to lower quality of the tea produced."

The second example is a manure mixture which contains in the following 9 constituents 7 sources of nitrogen:—

Groundnut cake.	Steamed bonemeal.
Whale Guano.	Mineral phosphate.
Bloodmeal.	Sulphate of ammonia.
Castor cake.	Nitrate of potash.

Muriate of potash.

Experimental Approach

Most of the statements in this somewhat formidable list were capable of experimental verification, so the next stage in the enquiry was to look for confirmation in published records. There were but two sources of information, the experiments on Pittakande made by the late Joseph Fraser, and those of the Department of Agriculture. Both these sets of experiments gave highly anomalous results, such as the plot with the least manure in the nitrogen series giving the highest yield but one in the Pittakande experiments, and the complete fertilizer plot being bottom but one in the Peradeniya series.

It was evident that my department would have to make field experiments its main concern, and that work would have to start at the very beginning. There was no doubt that the disappointing results from previous experiments was due to their lack of accuracy. It was essential to discover why experiments were inaccurate and whether anything could be done to improve them. Was it possible to assess experimental accuracy and could experiments of known accuracy be interpreted objectively, i.e. so that other workers would draw the same conclusions from the same results? These questions had been engaging people's attention in Europe and England and the broad principles that would have to be adhered to in order to achieve what the scientist calls accuracy or low error, and what I will call representativeness, had been worked out, notably by Professor R. A. Fisher. It had been my good fortune in conjunction with Fisher to make the first practical tests of these principles, and it was accordingly possible to start work on similar lines even before the results had gone through the somewhat lengthy process of being written up and published in the scientific journals for general information. The Tea Research Institute accordingly "got in on the ground-floor". For two years before the Institute acquired an estate, problems of field experimentation occupied the department's attention with the result that, when actual agricultural experiments were started, it was possible to ensure that differences between treatment yields as small as 6 or 7 per cent should be reliably interpreted.

From the point of view of advisory value many experiments fail in scope if not in accuracy. By keeping the treatments small in number, certain advantages making for accuracy may be gained. The demonstration of the effect of the presence or absence only of a single nutrient has however a distinct limit in usefulness, and as quantity was an important consideration in the list of "principles" previously stated, it was desirable that varying combinations of manures and quantities should be tried.

From the questions so freely discussed, three were chosen as a start. These were: what is the effect of nitrogen in three increasing quantities at three different levels of potash; what is the effect of

potash in three increasing quantities at three different levels of nitrogen; and how do inorganic sources of nitrogen compare with organic? That was as far as I considered we could go at that time; phosphate was kept constant as it was not then known how to vary phosphate too without invalidating the accuracy of the other portions of the trial.

At the end of the first cycle, owing to work done in the meantime, it had become possible to extend the experiment to different quantities of phosphate too, so that altogether the experiment demonstrated 27 different combinations of quantities of manure and three different types of nitrogen. In our first ten-year plan we have covered the behaviour of the three main nutrients and systematized the knowledge regarding them. Let me try now to answer some of the statements on which this exploration was based.

Experimental Results

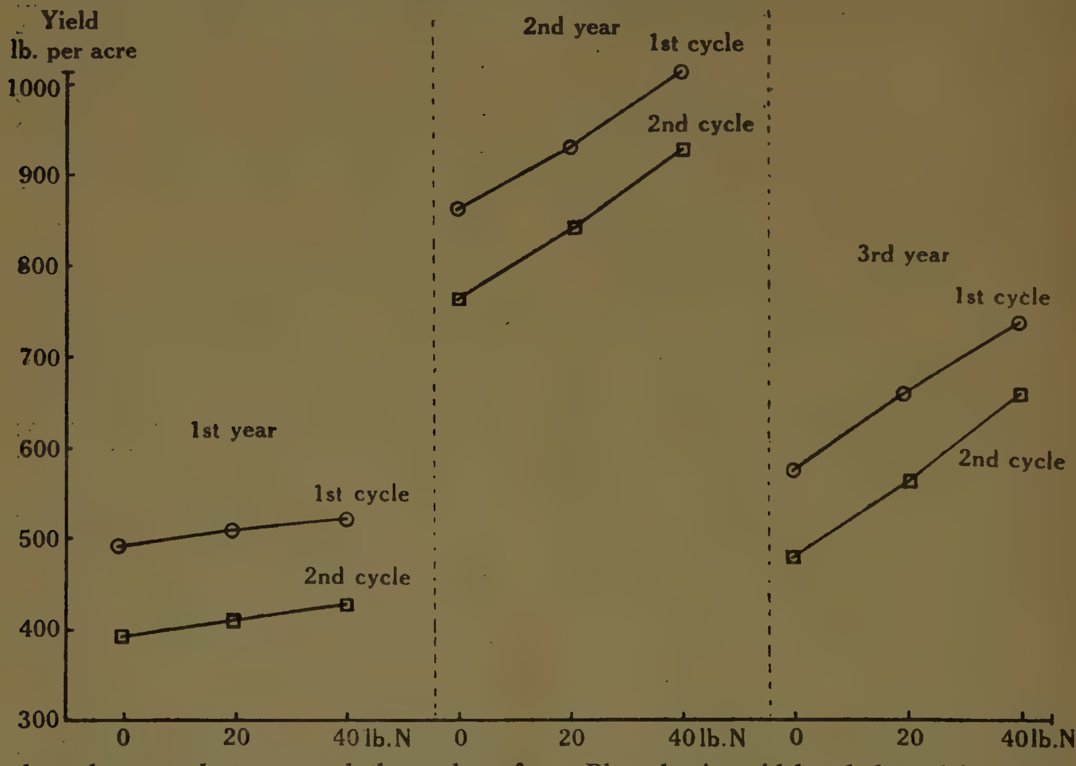
The nitrogen response has been demonstrated beyond dispute, as is shown by the diagram of yields obtained in the first two cycles. There is here no question of the lowest quantity of nitrogen coming out near the top of the list. What is striking is that there is a quite definite proportionate response of yield to quantity of nitrogen in the presence of the other nutrients: there is so far no sign of the operation of the law of diminishing returns which postulates that the return from each successive increment of nutrient brings diminishing increments of crop and consequently of profit. As far as yield is concerned there is no doubt, under normal conditions, of the economic benefit of 40 lb. per acre of nitrogen. Provided that the dearest unit of nitrogen is not used there is a profit even making full charges for the manufacture of the extra crop, but as is a common experience, the cost of harvesting and manufacturing extra crop is rather less than check-roll averages owing to the more beneficial spread of some of the overhead charges in the cost of production.

Closely connected with my subject are the results of the experimental manufacture of the Biochemical Department which show that this extra yield has been achieved without the sacrifice of quality. At the end of six years' cumulative effect Colombo finds in 17 valuations an average difference of less than one cent in price in favour of no nitrogenous manuring. This amount is due almost entirely to one extraordinary favourable value which London failed to confirm. On the same series of teas, London found in favour of no nitrogen to the amount of 1/12th penny.

The experimental evidence on the question of "organic" nitrogen is equally clear. At the end of six years the excess yield due to sulphate of ammonia, an "inorganic" manure, in comparison with blood, an "organic" compound, amounts to only 2.58 per cent of the yield. This has not been accompanied by sudden rushes of crop after the application of "soluble" nitrogen, followed by a compensating period of starvation. On the whole, the curves follow each other very closely indeed. Groundnut cake which has been tried for a shorter time lags behind sulphate of ammonia by 4.3 per cent. There is a certain amount of nitrogen in cakes and blood which is practically non-available and to this extent over an extended trial one must expect a lag in yield from this class of manure, but the rest is to all practical purposes as available as sulphate of ammonia. This is supported by laboratory nitrification experiments and by what we know of the carbo-nitrogen ratio of blood and cakes. The relay-race hypothesis thus loses its significance. Nor is there reason to fear

the acid-producing properties of commonly used inorganic fertilizers. Experimental proof has been forthcoming that tea definitely prefers an acid soil and will tolerate none else. The quality valuations bear out this new conception. In the course of 15 manufactures, Colombo found sulphate of ammonia superior by an average of one cent compared with bloodmeal and half-a-cent compared with groundnut cake. London also put the value of sulphate of ammonia higher than

Turning to potash it is evident from the close similarity of the yields that potash response under ordinary conditions is negligible. The maximum difference between potash and no potash is under 2 per cent, but although yield shows no signs of falling-off there is some evidence of loss in quality. The Colombo results give no conclusive sign owing to one highly abnormal figure but London gives a consistent preference of ·64d. for teas having potash as manure.



the other two but reversed the order of preference for bloodmeal and groundnut cake. The superiority was expressed in exceedingly small figures, 1/22d. and 4/22d. for blood and cake respectively. In terms of practical value these figures merely confirm the equivalence of the various sorts of nitrogen, though the Colombo figure actually shows the difference in favour of sulphate of ammonia to be significant.

Phosphoric acid has behaved in a very striking manner. The doses used were 30 and 60 lb. per acre. The response to phosphoric acid is not great being only some 139 lb. in the three years but it is entirely confined to the lower dose: the extra 30 lb. gives no enhancement of crop. This is also confirmed by our experiments in Uva. Another sidelight given by the experiment is that when the total amount of phosphoric acid removed

from the ground by the crop is determined, it is found to be markedly less than any of the other constituents dealt with.

Pruning Mixtures

I want to turn now to another aspect of these results. The very regular way in which nitrogen acts in promoting yield increases is too striking to be accidental, but you will notice from the slope of the graphs for the two cycles that it is only in the second and third years that it is of marked effect. You will notice how the cumulative effect of manuring is checked by pruning. These figures leave little doubt that the pruning mixture is uneconomically used. In these two cycles the production of dry matter (including tippings) during the separate years of the cycle is as follows for the addition of one pound of nitrogen.

Pruning Year	*Second Year*	*Third Year*
2.2 lb.	4.0 lb.	4.4 lb.

This result calls in question the whole practice of putting on pruning mixtures as an encouragement to growth. It suggests that the early growth of a tea bush after pruning is conditioned more by bush reserves than by manure. This hypothesis is obviously one which needs a specific test and in the new pruning cycle the "pruning mixture" is being applied at 0, 3 and 6 months from pruning. So far, only the tipping growth has been harvested but the yields are highly instructive. At the time of tipping the first two times of application were already passed, the third application remains to be done. I have had no time yet to calculate the errors of these results, but the yields from plots which received a pruning mixture averaging 60 lb. of nitrogen immediately after pruning are only 2 per cent greater than those which have so far had nothing. The yields of those plots which had a dressing at 3 months are actually lower than those of both the other sets though not I fancy significantly so. It thus appears that considerable doubt is thrown on the efficacy of pruning mixtures both as regards time of application and phosphoric acid content. The remaining yields of this year will give an indication of when first year applications can best be applied: we are planning an experiment in which the pruning mixture is altogether omitted.

I think it can be fairly claimed that a considerable amount of information has already been extracted from this series of experiments and more will follow. I have spoken incidentally of the testing of different times of application: a further modification is that the level of nitrogen has been raised in the present cycle by 40 lb. for each plot, i.e. we now have doses of 40, 60 and 80 lb. This will not only prevent the nitrogen deficiency on some of the plots from ruining the experiment, but will give information that is urgently needed for its own sake.

I hope I have succeeded in showing you how an experimental scheme is conceived, developed and modified. I cannot go into technical details, but one of the features of the technique employed is that these developments and modifications which arise out of results already obtained, can be made without breaking the essential continuity of the experiment or invalidating its interpretation. The addition of phosphoric acid was made in a way that still left it possible to compare the members of the nitrogen and potash series as before; the differing times of application have in no way disturbed the interpretation of the other factors; nor has the general change of nitrogen level.

Practical and Economic Benefit

These results I claim are practical results; they are being used on a commercial scale on St. Coombs. On all the

points on which the findings of the Institute's experiments differ from the prevailing opinions of ten or less years ago, the policy on St. Coombs is to adopt the findings of the experiments. This policy has the unanimous sanction of the Committee appointed by the Board to work out estate policy. We use inorganic manures ourselves: our phosphoric acid level is kept down to experimental limits: we have discontinued the use of the pruning mixtures at pruning time and apply it four months later when the bush has a cover of foliage developing. As experiments progress doubtless estate policy will accurately reflect that progress.

Moreover these practical results bring economic benefit. Comparing the original manuring on St. Coombs with that now being used I find there is a saving of Rs. 7/- per acre exclusive of freight, which provides an additional saving of some 30 cents. If the whole expense of the Institute since its start is divided by five in order to allocate a fair proportion of expenditure to the Agricultural Chemical Department, that amount is less than the saving which would accrue to the industry *in one year* if only 20 per cent of the acreage under tea cultivation followed our principles in this one aspect alone.

There is a philosophical theory that matter only exists by being perceived. You probably know the old argument as to whether a clock strikes when you don't hear it. By paying no attention to the findings of the Tea Research Institute it is possible, using similar sophistry, to persuade oneself that the Institute has done nothing. I hope however that one result of this lecture will be to persuade you otherwise.

The Growing of Wattle and Production of Wattle Bark in Kenya

By W. G. LECKIE, *B.Sc., Senior Agricultural Officer, Department of Agriculture, Kenya Colony*

INTRODUCTION

The wattle tree is of Australian origin and was introduced into South Africa in 1880, where the greatest development of the wattle bark industry has taken place. Particularly is this so in Natal where conditions are favourable for the growing of wattle and in addition a ready market has been available for the stripped timber as pit props in the mines. This utilization of the timber is important as it gave a great stimulus to the industry. A return from one plantation in Natal showed that of the total receipts 56 per cent was obtained from the sale of bark, 33 per cent from pit props and 11 per cent from fuel. The industry has gradually extended and now many of the plantations are too far from rail for the selling of timber to the mines to be practicable. The mines also are using an increasingly large number of concrete props, so that Natal is being faced with the same problem as Kenya, namely, that of utilizing the timber.

Wattle is also grown in India but only to a limited extent, so that at present no surplus is produced for export.

Australia, though the home of the wattle, does not produce bark in sufficient quantities for her own requirements. This is accounted for by the fact that the readily accessible forests have been cut out and the cost of replanting these areas is too great owing to the high cost of labour.

Wattle was introduced into Kenya in 1903 with a view to producing fuel for the Kenya and Uganda Railway. It was found, however, that the wood burnt too quickly and its use was therefore unsatisfactory. The first shipment of ten tons of bark from Kenya was made in 1910 and the industry showed signs of progressing until the high freights during the war made export unremunerative. In 1920 exports recommenced, when there were approximately 10,000 acres under the crop, mostly European owned. The following figures show the development which has taken place in the industry since 1930.

YEAR	ACREAGE		EXPORTS	
	European	Native	Dry Bark	Extract
			Tons	*Tons*
1925	8,830	6,000	3,582	—
1930	11,250	20,859	4,107	719
1933	14,613	60,000	10,804	1,437
1936	16,681	100,000	12,045	5,513
1937	—	100,000	16,025	5,202

At the present time, practically all the other vegetable tanning materials on the world's markets are from indigenous trees and shrubs which take a long time to mature and which for this reason would not be profitable to cultivate.

In the United States of America about 50 per cent of tanning materials used are from the locally grown chestnut and since this supply is getting short the country will have to rely more on imported materials. The Tanners' Council of America point out that "Wattle bark's chief value lies in its quick penetration, good colour, capacity to blend with other tannins and tendency to dissolve insoluble tans."

Wattle is one of the most valuable and extensively employed of the tanning materials of the British Empire and is meeting with increasing popularity with British tanners. The bark is one of the richest raw materials and produces a light-coloured leather so much in demand. The future of wattle therefore looks bright, since the tree matures quickly and can be sown *in situ*. As other slow-maturing tans become exhausted, so the tanning world will rely more and more on wattle as a source of supply.

It has been suggested that synthetic tans may come into general use and so injure the market for wattle bark extract. So recently as 1932 C. O. Williams, B.SC., A.R.C.S., the eminent authority on tanning materials in South Africa, has stated that artificial tanning materials have been known for about twenty years and that so far the total amount used is only 1 per cent of that of vegetable tans.

True tannins are very complicated in their chemical structure and it is hardly likely that compounds will be produced artificially at a cost competitive with natural tanning materials.

As already mentioned, South Africa and particularly Natal is by far the largest producer of wattle bark. The belt in which wattles are grown is hilly rolling country with a rainfall of from 35 to 40 inches and, what is regarded as most important, this wattle belt is subject to mists. The temperature varies from light frosts in winter to 90°F. in summer, and the rains occur between September and April. Wattle land is situated at from forty to eighty miles from the sea at elevations of 2,500 feet to 4,000 feet. Soils vary from light to dark loams and are, as a rule, deep.

Wattle in Kenya

Although conditions of soil and climate in the Kikuyu Reserves are eminently suited to wattle growing, the bark produced was of poor quality up till as late as 1933. At that time Kenya bark was quoted at from Sh. 20 to Sh. 30 per ton less than Natal bark. In 1933 rules were instituted by Government whereby all bark grown by natives had to be inspected before sale. A rapid improvement in quality was thereby effected, so that to-day Kenya bark is approximately of the same value as that of Natal on the world's markets.

Wattle lands may be divided into first, second, and third quality sites. Ideal conditions such as are found in the Limuru area and in Kikuyu country at elevations over 7,000 feet are classed as first quality sites. Here one finds a rainfall of about sixty inches, deep soils and prevalent mists. In these areas trees will reach maturity at from eight to ten years and, provided proper thinning has been carried out, give a very heavy yield of bark and wood per acre. Second quality sites are found in the Kiambu area, and in Kikuyu country at elevations between 5,000 and 7,000 feet. Here the soils are deep, but the rainfall is lower and there is generally little mist. Third quality sites are found in the Trans Nzoia and Plateau. In the Plateau, soils are very shallow and in the Trans Nzoia the climate is warm and in both areas there is a total absence of mists. Here we find that if the trees are left for over seven to eight years they go down with physiological diseases such as "mottling" followed by gummosis, and the bark becomes corky and unsaleable. These diseases are caused by unfavourable conditions for growth. To be brief, wattle on third quality sites reaches a rather poor maturity early.

The above remarks are of a general nature and are not meant to apply to individual farms where the conditions may

not be the same as those obtaining over the area as a whole. There are also large areas suitable to wattle growing, for example in the Kericho District and the Kisii Highlands, which have not been mentioned.

VARIETIES OF WATTLE

Four species have been imported into the Colony, which are grown in other countries for the production of tanning barks, namely:—

Acacia mollissima, black wattle.

A. decurrens, green wattle.

A. dealbata, silver wattle.

A. pycnantha, golden wattle.

Black Wattle.

This species is the most extensively grown and in quality and quantity yields the best tan bark of all the wattles. The foliage is dark green and the leaflets (pinnules) are short and flat and closely crowded on the pinnae (Fig. 1). The young shoots assume a golden tinge and the flowers when they first appear are yellow, later changing to pale cream. Trees flower from June onwards but the main flowering is in October–December. Seed pods are narrow and much contracted between the seeds. The variety thrives in a fairly humid climate with a rainfall of from thirty-five to sixty inches. In the young stages it is liable to damage by frost and should not be planted therefore in valleys where there is this danger. Germination of seed is difficult to obtain, and the best results are obtained by burning or boiling.

Trees reach maturity in six to twenty years, giving an average of five to twelve tons of green bark and twenty-eight tons of timber per acre. The dry bark for export should contain not more than 12 per cent of moisture and not less than 30 per cent of tannin.

Green Wattle.

This variety has been found in small plantations in the Limuru area, but it is more commonly to be seen as single trees in black wattle plantations. The foliage is a brighter green than that of black wattle and the pinnules are much longer and finer and not so closely crowded on the pinnae. The tree has a feathery appearance and the flowers are golden-yellow, appearing in July–September. Seed pods are longer and not so contracted between the seeds and are, if anything, narrower than those of black wattle. Green wattle appears to thrive under colder conditions and is more resistant to insect attack. The bark strips easily at almost any time of the year, but it is thinner than that of black wattle, so that for trees of the same size the yield is less. This species, however, is a faster grower than black wattle and for trees of the same age the yield of bark per acre is greater. The tannin content is approximately the same as that of black wattle but the colour of the infusion is deeper, producing a darker tanned leather. This species grows well at elevations of 6,000 feet and over.

Silver Wattle.

This species resembles black wattle very closely but the foliage has a bluish-green tinge. The pinnules are slightly finer and are closely crowded on the pinnae. The flowers are golden-yellow, appearing in profusion in June–August. The trees are most easily recognized by the seed pods which are of a brown glaucous colour and are very much broader and less contracted betweeen the seeds than either of the previously described species. The bark is comparatively thin and of very inferior value for tanning purposes, containing only approximately half the tannin of black wattle. The colour of the infusion is dark. In view of the above and the fact that the species

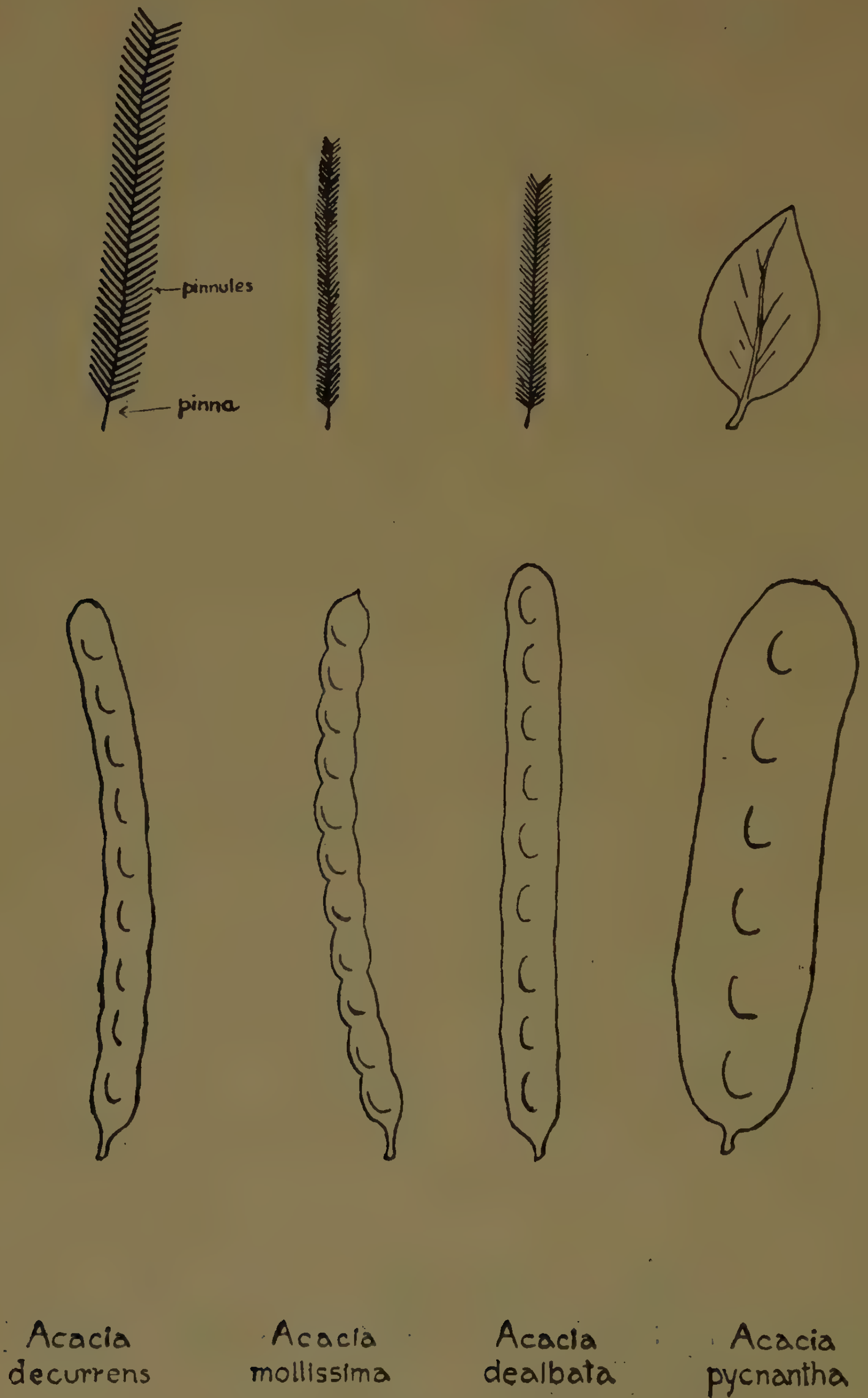


FIG. 1—Species of wattle

seeds and suckers readily, Government has forbidden its growth in the Colony (Government Notice No. 75 of 1931).

Golden Wattle.

This species is grown mainly as an ornamental tree and is readily recognized by its entire silvery leaves, as opposed to the feathery foliage of the species already described. The flowers, which appear in May to July, are yellow and larger than those of other wattles. The seed pod is almost one inch in breadth and is comparatively little contracted betweeen the seeds. The tree takes longer to mature and does not attain the size of black wattle; the bark is thin and so the aggregate yield is much less. The percentage of tannin is, however, usually higher, but the colour of the infusion is darker.

As golden wattle thrives on poorer soils and under much drier conditions than are required for black wattle is is well worth a trial in those parts of the Colony which are unsuitable for black wattle.

Black Wattle

Cultivation and Harvesting.

As black wattle is the main source of tannin and produces the best returns it is proposed to go into its cultivation and harvesting in Kenya in some detail.

This tree grows best in deep red chocolate soils with a rainfall of between forty and sixty inches. With a rainfall under thirty-five inches the tree makes but slow growth and when over sixty inches the bark is apt to become lichen-clad, which is detrimental to quality.

Soil Improver.—Black wattle belongs to the family *Leguminosæ* and shares the family's faculty of fixing nitrogen. With this and the large amount of organic matter it adds to the soil, it may be counted as a valuable soil renovator. On account of this fact it is quite a usual custom with natives to plant their trees on worn-out arable land. After a period of from six to seven years the humus and the nitrogen content of the soil are considerably increased and the land is again capable of supporting seasonal crops.

Seed.

Good seed is produced locally and can be purchased from estates having a permit from the Department of Agriculture.

Seed Treatment.—Black wattle seed, on account of its very hard coat, requires special treatment before sowing in order to obtain a good germination. The best results are obtained when the seed is poured into boiling water, the receptacle removed from the fire and the seed left to steep for ten to twelve hours; it is then spread out in a thin layer on sheets to dry. The usual practice which gives good results is to boil the seed for a period up to twenty minutes and then spread out to dry. It is important that the proportion of seed to water should be one to four. The drying should be carried out in the shade where possible. When thoroughly air-dry the seed may be bagged and stored ready for planting. Germination rather improves on storing for up to a year after treatment.

Preparation of Land.

Virgin Grass Lands.—Virgin land should be ploughed two or three months before planting, then disced and harrowed down to a fine seed bed when the rains break. A clean seed bed at this time will save a lot of expense in weeding later.

Bush Land.—In areas where the land is covered in bush it is possible simply to clear the bush, stack it in rows and plant the seed between these stacked rows of bush; but ploughing and harrowing in addition is to be recommended.

Sowing.

This operation is best carried out after the beginning of the long rains when sufficient moisture is assured for the seedlings to become established before there is any likelihood of dry weather setting in. In order to secure a good stand of strong growing trees and to control weeds and wattle regeneration, a fairly close initial spacing is necessary. Rows from 6 feet to 9 feet apart are recommended. It is important that sowing should be done along contours for reasons to be discussed under "Regeneration".

FIG. 2—Properly spaced trees ten months old

Method of Sowing.—Seed may be broadcast, dibbled, drilled by hand or sowed with a single row planter. The first method is very wasteful of seed and requires a lot of labour in subsequent thinning and lining out. Dibbling at stake is economical but may not give a sufficient number of plants from which to select strong trees. Drilling by hand is recommended for small acreages and sowing by machine for large acreages.

In sowing by hand shallow furrows are made with hoes and seed is "dribbled" continuously along the furrows and covered with an inch of soil. A boy who knows the work should be able to sow between one-half and three-quarters of an acre per day in six- to nine-feet rows.

Sowing by Machine.—An ordinary single row maize planter with a special plate to take wattle seed is used extensively in Natal. The plate can be made locally and has six $\frac{3}{8}$-in. holes. By altering the number of holes the planter can be regulated to plant from $1\frac{1}{2}$ lb. to 3 lb. of seed per acre. The object should be to get a continuous thin scattering of seed in the drill at about 2 lb. per acre. In order to keep these wide rows straight a light pole of the necessary length is tied to the mule's halter and a boy walks abreast holding the other end of the pole along the line of the previous row drilled.

Cultivation.

The wattle tree is a great water lover and surface feeder and it cannot obtain food and moisture, sufficient for its proper growth, in competition with a mat of grass and weeds. The object should be to commence with clean land and keep it clean by periodic light hand hoeings. Once a mat of grass and weeds has become established it is impossible to clean the land economically and all that can be done is to leave the trees eventually to smother the weeds.

Should the land be dirty at the time of sowing it is essential that narrow strips on either side of the rows of seedlings be cultivated and kept clean, otherwise the young plants will be smothered. Cleaning is necessary for the first eighteen months, by which time a canopy is formed and

weed growth smothered. The planting and cultivation of sloping land is discussed separately under soil erosion.

Inter-cropping.

Inter-cropping with seasonal crops may be carried out during the first two years from sowing, provided that—

(*a*) these crops are not planted within three feet of the young trees, and

(*b*) that the establishment of the wattle is looked on as the primary object and that of the seasonal crops as secondary.

Thinning.

It is of little value keeping plantations clean if very careful attention is not given to thinning. Dr. Craib, Forest Research Officer in South Africa, has shown that in order to obtain the best results thinning should be carried out very much more drastically than it is at present.

The first year in the life of a wattle plantation is of basic importance as the future returns are largely dependent on proper thinning during this period. In the first few months after planting the aim should be to secure a stand of approximately 800 uniform, evenly spaced, full crowned, seedlings per acre.

First Thinning.—As soon as the plants have attained a height of 6 inches they should be thinned out to 6 or 7 feet apart in the row. This thinning must be carried out by intelligent natives who will take the trouble to select the best plants at approximately the correct spacing. The importance of drilling the seed and not dibbling at 7-ft. intervals has been mentioned already and the value of this practice will be obvious at this stage in that there will be sufficient outstandingly vigorous plants from which a selection can be made.

Second Thinning.—When the trees have reached a height of 5 ft. they should be thinned to a stand of about 450 per acre, which means than in 9-feet rows the trees would be 10½ feet apart.

Further thinning will depend entirely on the vigour of growth of the young trees. Should growth continue at a rapid rate, with the formation of dense crowns and well developed lateral branches down to the ground, then a final thinning down to 250 trees per acre is advisable. This thinning is carried out when the trees are about 10 feet high at from eight to nine months old. Such drastic final thinning can only produce economic returns when an exceptionally good stand of vigorous growing trees is obtained. Should there be any doubt about the vigour of growth being maintained, the plantation should be matured at approximately 400 trees per acre.

In order to illustrate the value of adequate thinning as reflected in yields of dry bark, it is of interest to note that 850 trees per acre with an average D.B.H. (Diameter at Breast Height) of 4 in. will yield approximately 2.7 tons of dry bark per acre, while 300 trees per acre showing an average D.B.H. of 8 in. will yield 7.9 tons per acre.

Thinning Treatment in Neglected or Poor Plantations.—There are many plantations, especially in the native reserves, which have not received proper attention in the earlier stages and which present a problem as to the treatment most likely to improve the growth of trees and the yield of bark. Young plantations of up to two years, where growth has been fairly good, should be thinned to 450 trees per acre as early as possible; older plantations of up to five years, which show poor crowns owing to close spacing, to about 550 trees per acre. Where proper thinning has been neglected in plantations which are over

six years old a wider spacing for the trees is of no avail and such plantations are best clear felled. The bark, though thin, has a fair tannin content and can be marketed. In the native reserves some difficulty has been experienced in getting thinning carried out owing to the need for very small saplings in house building. This difficulty is being overcome by setting aside a small portion of each plantation in which thinning is not practised.

Rotation.

The economic length of the rotation will depend to some extent on the quality of the site, but mainly on the management of the plantation. Where thinning has beeen carried out on the lines described, the trees should be clear felled by the eighth year, regardless of site. On the better quality sites of Limuru it is possible that a further thinning in the sixth year may prolong the economic rotation to twelve years and over.

Crops of wattle have been grown successfully for four rotations without manuring the land. In order to obtain a continuous supply of bark and firewood the plantation must be divided into seven or eight blocks, one block being clear felled and regenerated each year in a rotation of seven to eight years.

Stripping of Bark.

The thickness of the bark, provided it is mature and has not become corky and black, is generally taken by the trade as an indication of quality. It is important, therefore, that the bark from the bottom of the tree should be taken. In order to obtain this, horizontal cuts are made in the bark, on the standing tree, three to four feet from the ground (Fig. 3). The bark is then stripped off from these cuts to the roots. The trees are then felled and the branches and tops bearing green bark are cut off, as this bark is of no commercial value. The bark is then stripped from the whole tree and should be tied in bundles and carted off to the extract factory, if one exists in the area. The rate of loss of moisture depends naturally on the weather conditions and whether the bark is immediately tied into bundles and put into wagons.

Fig. 3—Stripping bark

Mr. C. O. Williams carried out a number of experiments in which the newly stripped bark was tied into bundles, weighed and put into boxes to imitate the conditions obtaining in railway trucks. He found that on an average the loss of moisture represented 6 per cent of the gross weight after one day, 11 per cent after two days and 16 per cent after three days. The loss in weight when bark is dried under natural conditions varies with the age of the trees and the season of stripping. For practical purposes it may be reckoned that one hundred

pounds of freshly cut green bark will produce fifty pounds of commercial dry bark.

Drying Bark.

In areas where there is no extract factory it is necessary to produce dry bark to be exported as such or to be used by distant factories for the preparation of extract. Drying is the most important of all harvesting operations because, if it is improperly carried out, the bark is worthless. Heavy losses have been borne by exporters and others through bark reaching European markets in poor condition, the result of bad drying. As soon as stripping is completed the bark is rested, in single layers "bark side" uppermost, on poles on the ground. In this way occasional showers of rain are shed and the inside of the bark retains its light colour. The bark is left like this for anything from eight to twenty days until thoroughly air-dry. It is then tied into bundles, using three ties, and sent to the choppers. Bark is considered to be "air-dry" when it can be broken by the fingers and give a clean fracture. The aim must be to produce a bark of a light colour on the inner surface and absolutely free from any moulds or mildew. The colour is of the greatest importance because leather buyers and tanners insist on getting leather of a light colour. This can only be obtained when the bark is dried off the ground, with the convex (outer side) of the bark uppermost. Sun and rain beating on the inner sappy surface cause a deterioration both in the colour and composition of the bark.

Drying Sheds.

In districts where there is no dry season in which the drying of bark can be successfully carried out, it is necessary to erect drying sheds. These may have thatched or corrugated iron roofs and should be open at the sides. A large number of horizontal poles are slung from the rafters inside the shed, so that the strips of bark may be hung over these poles; or a system of overhead rails may be erected, so that the poles carrying the bark can be run out of the shed as the weather permits. Under the latter system the bark dries much faster and smaller sheds are required to handle the same quantity of bark.

A few years ago the bark was chopped by hand and exported in bags. Well equipped factories are now in operation at Thika where the bark is chopped or ground by machine, pressed and exported in bales. A considerable saving in freight charges is thereby effected, so that it no longer pays the grower to export his own bark.

Grading of Bark.

As already mentioned, wattle bark is exported in bales, either ground or chopped. It does not lend itself, therefore, to grading at the Coast and in any case a graduation, based on sight examination, into a number of standard qualities would be most difficult.

Millers have made a study of the world's markets and best know the various requirements in regard to quality. It is obvious that the sorting of bark, by growers, at the time of bundling would be of value and would enable the millers to offer better prices for the better qualities. Native bark is inspected by a Government inspector before sale and all immature and discoloured bark is rejected and destroyed. A premium is offered for high grade bark in one- or two-ton lots. In order to avoid wastage in the felling of immature trees travelling inspectors are now employed, who go round the reserves advising growers when the trees are ready for stripping. The cost of these inspectors is borne by a cess on the bark sold.

Regeneration.

For the regeneration of clear felled plantations a number of methods are in use, some of which entail the burning of brushwood and trash in order to obtain a good stand of seedlings. If the land is to remain productive the first object, after felling, must be to prevent erosion and the loss of humus. This can best be effected by collecting all brushwood and trash and laying them in lines along the contour. Where the slope of the land is steep the lines of brushwood should be well tramped down and should be spaced 10 feet to 20 feet apart. On more gentle slopes the spacing may be greater, but it will be found that on good land the close spacings require less labour than the wider and that the most economical method will be to stack the brushwood along the lines of the stumps. After some practice natives will be able to fell the trees so that they fall along the line of the stumps of the felled trees. In this way a great deal of labour in handling the brushwood is avoided. In order to lessen the risk of fire the rows of brushwood should be broken at frequent intervals.

The proper carrying out of this operation is of vital importance and natives should on no account be permitted to remove the brushwood for use as fuel. The system of regeneration entailing burning can only be regarded as ruinous.

Having decided that regeneration without burning will be pursued it is wise to hoe out any perennial grasses a few months before the plantation is clear felled. Brushwood piled about four feet high will smother weeds and wattle growth and will considerably lighten the cultivation required to establish the regenerated plantations.

Contrary to common opinion the seed shed from trees of six years and over will germinate without burning, especially if the soil is given a light hoeing along the lines of the proposed new rows.

Where for any reason a good natural regeneration cannot be obtained, narrow strips of about two-hoe widths are cultivated and seed is drilled in along these strips.

Manuring.

Wattles are particularly heavy feeders on calcium and potash. The latter element is normally present in abundance in this country, but calcium is, as a rule, short and should be added to the soil after three rotations. In Natal growers are advised to use 200–400 lb. of superphosphate per acre in order to increase the vigour of the young plants and reduce hoeing costs. Yields of bark have been increased by as much as 40 per cent through such dressings, and it would be well if growers in Kenya would apply dressings of 300 lb. superphosphate or 500 lb. bone meal per acre. The fertilizer is best distributed along the rows after sowing. If the seedlings are already through the ground the dressing should be applied on either side of the young trees.

The following figures obtained by Mr. C. O. Williams show the quantities of minerals removed in an eight-year rotation, per acre:—

	In wood	*In bark*
Lime* ...	260 lb.	169 lb.
Potash* ...	166 lb.	60 lb.
Phosphorus*...	19 lb.	8 lb.

UTILIZATION OF TIMBER

In native areas the poles and fuel are most valuable for domestic purposes. In fact many natives regard the production of bark as a secondary consideration. In European areas situated near rail or

*Expressed as oxides.

towns, all the timber can be marketed at the present time, as fuel or charcoal. The green timber is not very satisfactory for use in steam engines, but Mr. Hemsted, of Soy, found that if stacked for upwards of two years its value for this purpose is considerably improved.

Pit Props.—It is estimated that in South Africa 21,000 tons of wattle props are used in the Transvaal mines each year. The mines at Kakamega should be able to absorb considerable quantities of timber and it may not be amiss to describe the preparation and dimensions of the props required for mining. The timber should be stacked for three months to dry. At the end of this period it is transported to a sawing plant where it is sawn into 4 ft. and 6 ft. lengths. The props should not be under 3 in. diameter at the thin end. There is a certain demand for longer props of up to 12 feet, but these are usually cut to special order.

Other Uses.—Wattle poles will not stand for more than eight years, so that they are ruled out for any but temporary buildings or fences. Thinnings may be used as drop posts in fencing or for the rafters in roofs. The Imperial Institute report that the wood pulp is suitable for the cheaper grades of wrapping paper. For plantations situated at some distance from markets charcoal will provide the best returns per acre, an acre of mature trees yielding approximately $7\frac{1}{2}$ tons of charcoal.

Manurial value of wattle wood-ash.

	Per cent
Matter soluble in water—	
Potash*	6.98
Soda*	1.24
Matter insoluble in water—	
Potash*	.78
Phosphorus*	2.11
Lime*	45.80

As the lime and potash are principally in the form of carbonates the ash is particularly suited to application on sour soils, but less suited to alkaline soils.

Pests

Kenya is so far fortunate in having few major pests of wattle. Some damage has been done by leaf-eating caterpillars and by a capsid known as "frog hopper". The latter attack the young shoots and cause stunted growth resembling "witch's broom". The damage done by these pests is most noticeable in young plantations, but the trees quickly recover after the rains.

Soil Erosion and Wattle

The most serious soil erosion on wattle lands is to be seen either after the trees are clear felled, or when a fire has swept through the plantation. Methods for prevention in the former case have been discussed under renegeration. Fires in the better wattle-growing areas of the Colony are of infrequent occurrence, but in areas where the plantations are established on grass lands, suitable fire-breaks should be cut or ploughed round each block of fifty acres.

Erosion takes place to some extent in standing plantations, especially when the trees have been planted on slopes exceeding 25 per cent, or where surface water, from roads or tracks, discharges into the plantations. On slopes approaching 25 per cent it is desirable to establish the plantation in contour belts about 40 yards wide. Beginning at the bottom of the slope successive belts should be planted each year by ploughing or hoeing strips 3 ft. wide and 8 ft. apart along the contour, so leaving strips of grass or bush 5 ft. wide between the rows of young wattle. When the time comes for felling

*Expressed as oxides.

only one belt will be cut out and regenerated in any one year, thus providing for a continuous rotation and protection for the soil.

It is realized that the planting of slopes in this way entails considerable trouble and that the trees established under such conditions will not make rapid growth. The alternative is expensive, requiring as it does graded terraces with suitably spaced step drains.

Where surface water discharges into the plantation a step drain should be constructed to carry the water to the foot of the slope.

Costs of Production

Costs vary considerably in different areas, but are largely governed by the ability of the individual planter. On one farm visited, situated on veld land, the cost of ploughing, harrowing and sowing was only Sh. 5 per acre, while on other farms the cost may exceed Sh. 40 for the same work. Again some planters only obtain yields of about 3 tons of dry bark and 25 tons of timber per acre, while others obtain 6 tons of dry bark and 50 tons of timber per acre. The figures given below for costs and returns per acre are only intended, therefore, to serve as a rough guide, but they are assured in any wattle area of the Colony where trees are given proper attention.

	Sh.	cts.
(1) *Production Costs per acre*—		
(*a*) Ploughing, harrowing, sowing, cultivating and thinning, covering a rotation of eight years	55	00
(*b*) Felling, stripping and drying bark and cutting poles	25	00
(*c*) Transport of bark to rail, 10 miles, loading, etc....	17	50
(*d*) Rail freight	7	07
Total Costs ...	104	57
(2) *Returns per acre*—		
(*a*) $3\frac{1}{2}$ tons dry bark at Sh. 60	210	00
(*b*) 30 tons of fuel and poles at Sh. 4 on plantation ...	120	00
Total Returns ...	330	00

Disregarding interest on the capital investment in the land, a return of Sh. 28 is thus obtained per acre per annum on an eight-year rotation.

Conclusion

Since 1930 the wattle industry has made remarkable progress, especially in the native reserves of the Colony. The prospective grower may look forward to a small annual return per acre which is little effected by droughts or locust ravages. The over-production of bark is unlikely for some time and the manufacture of a synthetic tan equal in quality and price to wattle is very remote.

An Indigenous System of Soil Protection*

By B. J. HARTLEY, *M.B.E., N.D.A., A.I.C.T.A., Agricultural Officer, Department of Agriculture, Tanganyika Territory*

The Erok people of Mbulu District inhabit the mountainous country which rises between the Great Rift Valley and the Yaida and Eyassi depressions. The origin of the tribe is obscure. S. B. Leakey (*Kenya, Land of Contrasts and Problems*), has suggested that they may be the descendants of neolithic people of the type inhabiting the City of Engaruka, whence Masai history records the Mbulu District tribes fled. Whatever their origin, these people have an intelligence which appears to be above the type shown by the ordinary Bantu peoples.

Under pressure from the Masai on their northern flank and with treacherous neighbours in the Tatoga peoples, the timid Erok were, for some time before the advent of the European, confined to a limited area which they had carved out of the forest clad mountains. Like other tribes in similar circumstances, such as the Wamatengo and Wakara, they evolved a system of soil conservation.

The slopes under cultivation would deter almost any but those who find it necessary to eke out a living there, but a favourable rainfall and a not infertile soil compensate for the considerable labour required to a farm on the Erok system.

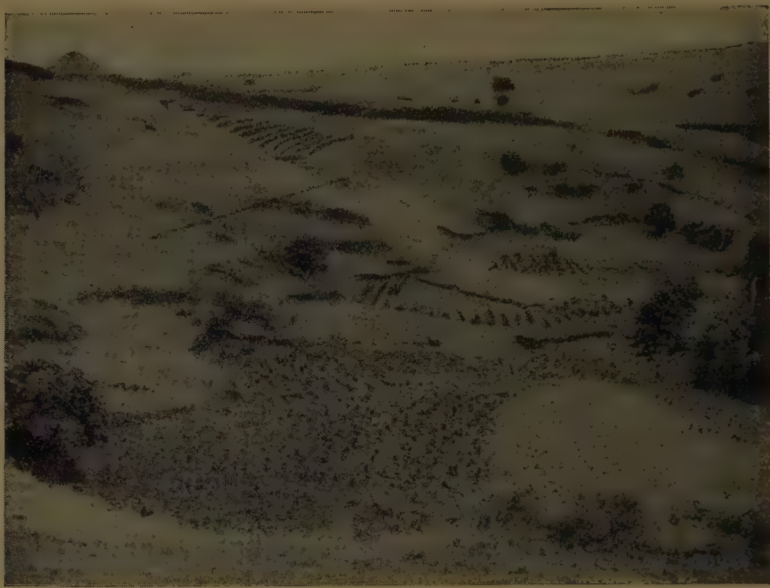
Land for cultivation is whenever possible selected in the steep and narrow valleys. The fields are of small size, generally about one quarter of an acre and are made to occupy a single "terrace". These terraces are in the early stages protected by a storm drain above the field and cultivation is designed to work the soil away from the slope until it is level. Owing to the steepness of the slopes and the adjustment of a field to each terrace, the vertical interval between the terrace edges is considerable; for this reason a perfectly level terrace is only seen in favourable situations. The climate provides an all-the-year-round growing season and enables the cultivator to protect his terrace edges with grass and crops; as a result the usual deterioration of the terrace edge so commonly seen in drier situations does not occur.

The formation of a terrace is a gradual process. After the construction of a storm drain, followed by the pulling down of soil from a face say three feet deep, and the provision of a Kikuyu grass verge on the edge of the terrace, cultivation will proceed.

Old fallow land or new land is deeply cultivated with a long digging pole which turns over the sod, leaving a very deep broken surface to weather in the cold season. With the advent of the true short rains season and higher temperatures this land will be contour planted between small ridges with (say) maize, while a strip of pumpkins is established on the lower side of the "terrace" to afford additional protection. At hoeing time the ridges are commonly reinforced according to the season and the amount of rubbish which may have been buried. In some cases the ridges may be split back to earth-up crops; but still naturally retain their soil and water conserving principle.

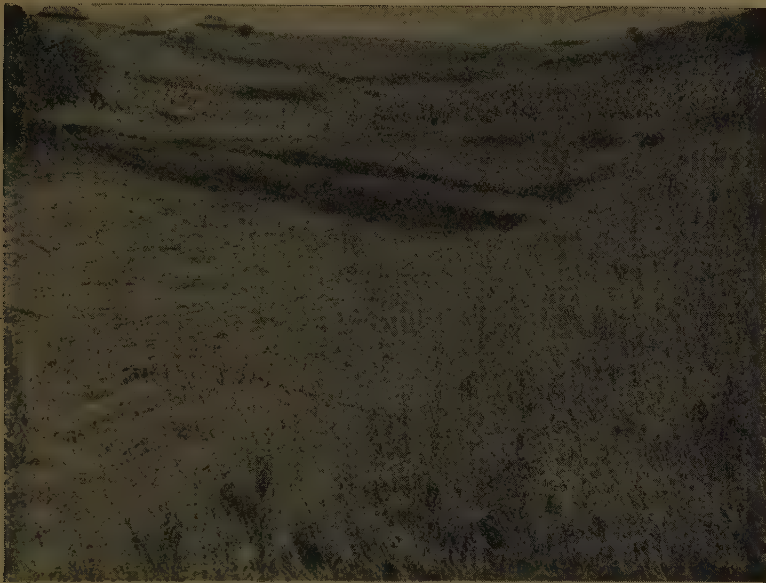
Important practices affecting the terraces occur when the next planting takes place. Assuming that a short rains crop has been removed in May, the cultivator's next work is to chop out the

*Previously appeared in Vol. III, No. 4, *without* illustrations.



Fields in the Kainam area, with crops planted in contour lines of field terraces

View from below the edge of a terrace showing on the right a strip of pumpkins planted just above the Kikuyu grass bank



A field terrace, showing thatched ground

An Iraqw field landscape

stover and lay it evenly over the field. The value of this thatch in conserving moisture is understood by the Erok cultivator, who could well do with such stover as forage for cattle from his overstocked grazing. When cultivation takes place this stover is drawn into lines starting at the lower side of the terrace, then ridged over and the seed planted at once between the ridges; in the process of ridging the soil is pulled downhill and gradually season by season the terrace is formed.

well repay investigation elsewhere under varying conditions of rainfall.

Soil movement within the plot under this system is reduced to a minimum while at the same time loss from the terrace is adequately controlled. Wash from land surrounding the cultivated terrace is, in the old Erok country, of little danger on account of the presence of a fair grass cover, while depth of soil assists in the formation of the terraces, many of which have faces twelve feet deep.

Fields planted without protection on the Aitcho escarpment—an area formerly occupied by pastoral tribes only, but now in process of settlement by Iraqw cultivators

To those experienced in the dangers of even green manuring under dry conditions it seems remarkable that a heavy stand of dry stover can be so disposed of after the heavy rains without any noticeable effect on the following crop. Too often trash and weed growth is burned or eaten off in the field owing to difficulties of disposal in the soil; this Erok method of sowing a listed crop between the ridges carrying rotting crop residues is a development which would

The problem which now confronts Government is the introduction of anti-soil erosion measures to the members of the tribe who have moved from their ancestral fields to the drier, less mountainous areas. Here, overstocking, flat cultivation and rainfall more of the unstable type found in semi-arid areas, provide ideal conditions for wide-scale soil damage. The Erok, no longer afraid, is content to cultivate and move on; he has become a miner instead of a farmer.

The Ayrshire for Intensive Dairying

By E. N. MILLINGTON, *Kivulini, Molo, Kenya Colony.*

In the choice of a breed of cattle for dairying, personal preference frequently enters into the question and up to a certain point it is well that it should be so, as success is more likely to be obtained —other things being equal—with a breed familiar to the farmer or with one which pleases his eye. With most farmers, however, practical and financial considerations rightly dominate the selection of the breed.

The claims here put forward for the Ayrshire are not expressed in any sense of breed rivalry, as few will deny that the Ayrshire has certain inherent characteristics not possessed in the same degree by other breeds and likewise other breeds have their special qualities which are perhaps not so freely given to the Ayrshire. The aim of this article is to suggest how the Ayrshire cow's characteristics fit her for intensive dairying a little better than other breeds. In passing, it should be observed that these attributes do not in any way imply that she is suitable for intensive dairying *only*, as in point of fact, she has proved herself one of the most adaptable and all round satisfactory cows in the world.

On what grounds therefore can the Ayrshire be so strongly recommended for intensive dairying?

Briefly—

(*a*) She produces large quantities of milk averaging 4 per cent butter fat which meets every requirement and which is universally popular.

(*b*) She is hardy, long-lived and active.

(*c*) She is a most economical producer of both milk and butter fat.

The foregoing statements need amplification:—

(*a*) An intensive dairy farm is usually a comparatively small one and is not infrequently situated within reach of an urban centre. When this happens to be the case, the dairy products will most likely be sold as milk and/or cream for consumption as such. It is here that the Ayrshire excels; she produces ideal milk for this purpose; milk, which with its small fat globules and soft curd render it especially valuable for children on account of its easy digestibility. Its liberal percentage of butter fat is undoubtedly a source of satisfaction to consumers, thus creating a demand for Ayrshire milk. In Kenya, urban centres are comparatively few and many small farmers are dependent on selling their dairy produce in the form of butter fat. Ayrshires give very satisfactory returns of butter fat, and also of separated milk—a very valuable commodity to the intensive farmer for his dairy heifers and for his pigs.

(*b*) Together with production must be considered those most important points, hardiness and longevity, which, it is claimed, are possessed in such a high degree by the Ayrshire. So important are these points that to-day very much more attention is paid to lifetime records than to spectacular records over one or two lactations.

It must be realized that the intensively managed cow has an infinitely harder working life than her semi-ranched sister. She is fed much more heavily on concentrated foodstuffs, is mated, as a general rule, considerably earlier in life, is almost invariably a high or comparatively high producer and as a result of

these somewhat unnatural conditions, is subjected to far greater strain. Her digestion and her milk-producing machinery and vessel have had to accommodate themselves to man's demands for increased production. As a result, "breakdowns" are common and in some countries the average life of the intensively managed cow is but three or four years of usefulness.

It is an old saying: "No foot no horse" and with equal truth it might well be said: "No udder no cow". The Ayrshire's symmetrical udder which is is so strongly and snugly carried—thus minimizing dirt, disease and accident to this vulnerable organ—is of itself sufficient to recommend her to the intensive farmer. She is deservedly noted for her hardiness. Her adaptability to all sorts of conditions is manifest by the fact that Ayrshires have been exported from their home to almost every country in the world and have made good in all climates. It is of interest to note that in Sweden (a country of intensive dairying whose principal export of dairy produce is in the form of butter) Ayrshires are numerous and popular.

(*c*) It has been stated on good authority that Ayrshires make the most 4 per cent milk at the lowest cost. On an intensive farm of presumably small acreage, the amount of roughage consumed may be an important item. The Ayrshire is a rustler and will live and produce milk on indifferent grazing, but she will respond handsomely to the improved pasture and feed likely to be provided by the intensive farmer. It may be argued that the bull calves have not such a potential value for slaughter purposes as those of, say, a dual purpose breed. At first sight there may appear to be something in this argument, as the Ayrshire is definitely a dairy breed. On an intensive farm, however, there is not likely to be much room to run a steer herd and most intensive farmers would prefer to be rid of nearly all their bull calves at birth, enabling them to give more attention to their best heifer calves and to sell more dairy produce.

The following is an extract from an article written by Professor A. D. Buchanan-Smith of the Institute of Animal Genetics, Edinburgh University, and is quoted here to show that the business end of the Ayrshire was being stressed by Ayrshire breeders one hundred years ago:—

> "If we look at the portrait of Ayrshire cows in the year 1828 there is a point which must immediately strike every breeder of Ayrshire cattle. The characteristic of the cow—and it is the characteristic not seen in portraits of other breeds at the same period—is that the udder is long and carried well forward to well developed milk veins. If we study the standards laid down by the Ayrshire Agricultural Association one hundred years ago, we find that this point of the udder is definitely stressed."

In speaking of Ayrshires in this article the writer does not necessarily refer to pedigree or purebred animals, but rather to grades which have been bred to type by the continued use of Ayrshire bulls.

To farmers who have recently taken up dairying the following notes on the management of a herd of grade Ayrshire cattle on a small and intensively managed farm in the Kikuyu grass area may be of some interest:—

> "The suitability of the breed for Kenya conditions is based largely on its ability to produce large quantities of butter fat at relatively small cost. The Ayrshire does not require excessive quantities of coarse fodders, since

its frame is not particularly large and this in itself makes it more suitable for ranching conditions. Furthermore the breed is dominant in crossing and quickly establishes a type when purebred bulls are used on low-grade cattle of mixed origin. Some of the most successful Ayrshire herds have been built up in Kenya from Shorthorn foundation stock sired by a purebred Ayrshire bull, the first cross having proved excellent milkers with sound constitution. Even under rather exacting ranching conditions, when little, if any, feeding is practised, the Ayrshire has shown its ability to maintain condition over fairly prolonged dry periods."

The foundation cows were mostly grade Shorthorn but purebred Ayrshire bulls have been used since the inception of the herd some ten years ago. The bulls used are selected with due regard to regular breeding on the dam's side, good milk records, say from 800 to 1,000 gallons at 4 per cent butter fat or thereabout, good constitution and conformation. The aim is to achieve a herd average of 650 to 700 gallons. The bulls do not run with the cows and the penis and sheath are washed with a *mild* disinfectant after service as a matter of hygiene. This takes only a few minutes and may possibly save many pounds.

Calves are taken from the dam at birth and are hand raised in separate pens in the usual way, being switched over to separated milk at six weeks, when they are fed in addition as much concentrates as they will clean up, to a maximum of 3 lb. a day at eight to nine months. Bull calves are slaughtered at birth or a few sold as vealers. Heifers are usually bulled at about two years.

The basis of feeding in addition to the grazing which is for the most part of fair value all the year round is as follows:—

Dry weather.—Maize silage is relied upon for succulent feed as on this particular farm it has been found the easiest, cheapest and most palatable silage to produce. This with the grazing appears to provide ample for maintenance and the first gallon or gallon and a half of milk. Supplementary concentrates are fed at the rate of 3 lb. per gallon over this.

Wet weather.—Strange as it may seem this period presents more difficulties than the dry weather on account of the extreme lushness of the grass. The principal control exercised is that of keeping paddocks as heavily stocked and grazed as is possible and by liberal feeding of good lucerne or grass hay. Newly calved cows and cows giving two gallons and over are fed 3 lb. per gallon after the first two gallons, of a ration high in carbohydrates. Smaller amounts of silage are fed, as, although laxative, its carbohydrate value blends with the high protein content of the grass.

A Note on Termite Hills

By G. AP GRIFFITH, *Ph.D., B.Sc. (Wales), A.I.C.T.A., A.I.C., Chemist, Department of Agriculture, Uganda*

Although they have received little attention from soil workers, termite mounds form perhaps the most characteristic feature of the landscape of the greater part of Uganda. They are undoubtedly of considerable importance in the processes of soil formation and in the general economy of the land. This is amply illustrated by the fact that many plant species are almost entirely confined to termite hills, indicating the special nature of the soil of which they are composed.

There has always been a sharp divergence of opinion as to the agricultural value of the mounds, some holding that they are entirely harmful and others expressing the opposite view. The following discussion may help to reconcile these views.

One of the features of termite hills is their variation in shape, the most common shapes in Uganda being a conical mound averaging about eight feet in height and a broad-based mound of smaller average height. It is suggested that the factors which determine the shape of the mound are the texture of the original soil, the climate, and the species of termite whose home it is.

The conical mound with steep sides is typical of the slopes of the moister areas where the soil is red earth of fairly heavy structure. The broader and shorter mound would appear to be associated with the lighter soils which are also the soils of the drier areas. In the red earth districts a similar mound is formed in the depressions. In general it is in the drier areas that the termite mounds have the reputation of growing better cotton than the surrounding soil, whilst in the red earth areas they are more usually infertile and a hindrance to agriculture.

A number of termite hills from different parts of Uganda have been sampled and samples of soil from nearby have been taken in each case.

The following table gives the analyses of these samples.

Sample	Soils From	Moisture Percentage at Point of Stickiness	Organic Carbon	Available Nutrients		
				P_2O_5	K_2O	CaO
A	Mound in red earth area (Kampala) ..	36·4	1·00	·0022	·072	·084
	Near A	23·3	2·39	·0026	·083	·155
B	Mound in red earth area (Kampala) ..	31·4	1·49	·0041	·068	·168
	Near B	24·3	2·06	·0072	·054	·215
C	Mound in North Busoga. Best cotton always on mounds	29·7	1·08	·0018	·052	·409
	Near C	29·7	1·11	·0017	·027	·123
D	Mound in Chua. Best cotton grows on mounds	14·5	0·83	·0064	—	·345
	Near D	21·9	1·18	·0060	—	·089

It is seen that in all cases the percentage of organic matter in the soil from the mounds is smaller than in that from near the mounds. In the Kampala area the available nutrients are also lower in the mound soils. In the case of C and D, however, the available nutrients are very considerably higher in the soil from the mounds than in that from the flats, the difference being most marked in the percentage of available calcium.

It is a common observation, first made in Uganda by the present writer in Bugerere and afterwards confirmed in other parts of this country, that in the drier areas flecks of calcareous material are exposed on the surface of termite mounds. Milne (Soil Chemist, Amani) in an unpublished account of a journey in Tanganyika has commented upon similar occurrences there and has advanced some interesting alternative explanations of the mode of formation of this calcareous deposit.

Whatever other factors play their part in this accumulation of calcium it seems clear that physical factors are of importance in deciding the role of the termite mound.

Thus in the red earth areas, as has been stated, a steep-sided cone of compact soil is formed, off which any compact organic resides are quickly removed and on which seeds cannot readily establish themselves.

In the drier areas the soil is lighter and less compact and a mound with less steeply sloping sides is formed. The typical appearance of the countryside is that of stunted and sparse tree growth with ample scope for wind action in the open spaces which are inadequately protected by grass, etc. The termite mounds here tend to provide a resting place for the organic residues blown from the open tracts. Bird and animal droppings and seeds are not so rapidly washed away. These factors give vegetation on the mounds a slight initial advantage which, once cover is established, is of course cumulative. Finally the slightly raised situation gives the vegetation some immunity from fire.

Fodder Conservation

The prolonged dry season has emphasized the value of an adequate reserve of fodder in maintaining the condition of young and adult stock. Where grazing is becoming scarce on the smaller farm it is necessary to provide a large amount of coarse forage and the value of such crop residues as pea haulm, oat straw and barley straw, becomes evident. To improve the feeding value of oat straw it is advisable to cut the crop in an immature condition and dry it in stooks before threshing. In this manner the straw retains a considerable amount of its value. This coarse fodder should be fed to the animals in racks or spread on the ground during the day; in addition they should be receiving succulent feeds in the form of silage and sprouted grain. The latter is proving of considerable value in the maintenance of milk yields during the dry season, and for those farmers who are nearing the end of their tether as regards a reserve of succulent fodder it is an opportune moment to commence to prepare this feed. This method can also be used as a means of supplying green fodder for poultry when supplies of kale, cabbage, etc., become exhausted with a consequent fall in the egg yield.

R. S. B.

A Note on the Rooting of Derris Cuttings by a Root-Promoting Substance

By J. GLOVER, *M.Sc., Plant Physiologist, East African Agricultural Research Station, Amani*

The experiment was designed to test whether the root-promoting substance beta-indole-acetic acid would produce an increased rooting response in the already easily rooted cuttings of Derris and if such a response could be easily detected.

The material used in the experiment was obtained from the Amani strain of *Derris elliptica* plants. As the plants were reproduced vegetatively from cuttings of a single plant at Kew they may be considered to be a clonal variety. The cuttings, all from healthy plants, were selected for their uniformity of length and thickness. There were three nodes on each. Of the 700 cuttings used, 350 were treated by immersing their basal inch for 24 hours in a 1/20,000 solution of beta-indole-acetic acid in distilled water; the 350 control cuttings were similarly treated with distilled water only. The cuttings were arranged in randomized plots, fifty in each. The plots were arranged in seven blocks to facilitate analysis of the results for possible variation in rooting response due to the position of the plots in the propagating bed.

After two months in the nursery bed the cuttings were carefully excavated and the number and lengths of the roots on each cutting were recorded. The results, when analysed for inherent variability and error due to position in the nursery bed, are given in the Table below:—

	Treated	Controls	Difference of Means	Significant Difference
Mean number of roots per plot	1,118	564	554	334
Expressed as % of the General Mean.. ..	133	67	66	40

From the above table it can be seen that treatment by a root-promoting substance does increase the production of roots, even in the quickly rooting Derris cuttings.

To analyse the results further the roots were divided into length classes (every .05 inch) and a frequency diagram was prepared showing their distribution between these classes. This shows that the significant gain in number of roots produced by the treated cuttings over those produced by the controls extends to all groups, except those shorter than .2 inch. There the slight increase shown by the treated cuttings was not statistically significant. The groups below .2 inch contain nearly all the newly initiated roots, so apparently towards the end of the experimental period the rate at which the treated plants initiated roots approached that in the control plants. As the root system of Derris is the economically important part of the plant, it is of interest to know whether the treated plants will retain the lead already given them or whether after a time the control plants will "catch up" and nullify the original gain. At the end of two months no overtaking is apparent and both sets of plants are producing roots at approximately the same rate. If this continues, then treatment by root-promoting substances may be of value in increasing the final yield of root.

The preparation of the cuttings for treatment and their subsequent planting in the nursery bed were carried out by the African staff who normally carry out the propagating work. The total cost of treating the 700 cuttings was 15 cents of a shilling.

Correspondence

RAMIE

Sir,

In the March issue of the *Agricultural Journal* I notice that Mr. Sabner says in his letter about ramie that the average production of the Chinese is about 3 lb. of hand-cleaned fibre per hour. Also that he had in mind several ways of improving a method so that the natives of East Africa could produce 30 to 40 lb. of hand-cleaned ribbons a day.

When we were working experimentally with this crop in Tanganyika we found that to strip the "peel" off by hand proved to be a more expensive business than we anticipated, not to mention the further treatment of that peel to produce hand-cleaned ribbons. Accordingly I looked up the literature to find out what the performance was elsewhere. This is what I found. In China one man can produce from 2 to 6½ lb. of China grass a day. On an experiment in Louisiana 10 to 13 lb. of ribbons were produced a day. Ribbons give about 50 per cent workable fibre when degummed whereas China grass gives 70 per cent degummed filasse. On an estate in India the labour for peeling and scraping to produce 950 lb. of fibre was stated to be seven men daily for three months, the output would therefore work out at about 5 lb. of fibre per day per man. The native method at Bhagalpur is a combination of slow boiling, beating, washing and using notched boards. Two men, two women and two boys can treat enough material to produce about 2 lb. of fibre in a day.

A small experimental machine used in America was described as treating two tons of green plants every ten hours. This would produce 52 lb. of ribbons containing about 20 lb. of pure fibre.

I find it most difficult to reconcile these figures with the statement that the average production of a Chinaman is 24 lb. of China grass in an eight-hour day or that a method can be devised with which there should be no difficulty for the native of East Africa in producing 30 to 40 lb. a day of hand-cleaned ribbons.

I am, etc.,

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Reviews

Bronze Leaf Wilt Disease of the Coconut Palm, by F. M. Bain, Department of Agriculture, Trinidad, B.W.I., 48 pp.

Plant pathologists have always found the coconut palm a difficult patient. In particular the trouble, referred to generally as "Bud-rot", has often proved a baffling problem. In the British West Indies, the work of Stockdale and Nowell led to the recognition of three types of bud rot; one a true rot due to the fungus *Phytophthora palmivora,* and another a secondary rot following a stem infection by a nematode. There remained a third type for which no cause could be found.

This third obscure type, now termed "Bronze leaf wilt disease", forms the subject of recent studies by Mr. F. M. Bain. He has attempted to relate the incidence of wilt to the soil conditions in which the plant is growing. His general conclusion is that the disease is a physiological die-back, resulting from a water-deficiency in the plant; and that this water-deficiency may arise either when the plant is growing in a soil of low water-retentive power or in a soil where periodical water-logging leads to the death of many roots. Unbalanced nutrition, and in particular a shortage of potassium, may be a contributory factor. The author recommends certain preventive treatments feasible on some of the soil types, and recognizes that on others the only sound course is to abandon coconuts and grow other crops.

Plot Size in Coffee Experiments.

Before undertaking yield trials with any crop one should know the variability of the crop one is dealing with and from this determine the best size of plot to use as, for economic and other reasons, it is desirable that the experimental areas should be kept as small as possible. During recent years much research has been devoted to this subject, chiefly with annual crops, but until uniformity trials were begun at the Coffee Research Station, Moshi, Tanganyika, little or nothing was known about the problem as it affects coffee. In an article by S. M. Gilbert, published in *Tropical Agriculture,* Vol. XV, No. 3, this work at Moshi, which began in 1934, is described.

Two blocks of approximately eight hundred trees were selected for this study of plot size, each tree being numbered and each picking recorded over a period of three years. In the statistical analysis of the yields, a 4 x 4 Latin Square was used, the same square being reimposed at random on the plan for each plot size. The inclusion of trees in any one plot was consequently determined by chance.

A description of the experiments, the methods used and a discussion of the results are given, the general conclusion being that under the conditions of the two estates examined twenty trees per plot appear a suitable size.

Arising out of the experiment various interesting observations are given; e.g. that in any given plot there may be: (1) trees which always remain poor yielders due possibly to genetic factors, age or environment; (2) trees which are very pronounced biennial bearers while neighbouring trees may not always be in step with this habit; and (3) trees which under good conditions of growth can respond to a considerably greater extent than their neighbours.

A. G. G. H.

THE MAN-MADE DESERT IN AFRICA, EROSION AND DROUGHT, By E. P. Stebbing, M.A., F.L.S., F.R.G.S., F.R.S.E., Supplement to the *Journal of The Royal African Society*, January 1938, 40 pp.

The weather, apart from being an inexhaustible topic of conversation, is of vital concern to those whose livelihood depends upon sun and rain in the right proportions and at the right time. A drought at the right time, if such a phrase can be used, is a natural enough happening over which man has no control. In his paper Professor Stebbing maintains that the word drought, as ordinarily used, cannot be properly applied to what happens when man, by interfering with nature, brings about a succession of arid seasons which results in a failure of agricultural and pastoral industry and ultimately turns fertile land into desert. The distinction, though important, is unfortunately not clearly understood by most people who are still apt to think of the disastrous occurrence as having come from "the hand of God" and that in due course the normal rainfall will return. The Dust Bowls of North America and the soil drift in Southern Australia are outstanding examples of the drying-up of water supplies and the falling off in the rainfall because of what man himself has done. It is held that such a state of affairs as these portray can no longer be termed "drought", but that it should be termed the "Intermittent Stage in Water Supplies".

Similarly there appears to be confusion as to what is meant by erosion in various parts of the world. More for the convenience of the man in the street than with text book exactness the kinds of erosion are therefore classified into seven different types and, although the paper is written about Africa, illustrations are quoted from the United States, Canada, Australia and India. The types are: (1) Sheet Erosion; (2) Soil Erosion due to over-cultivation; (3) Soil Erosion due to excess pasturing; (4) Soil Deterioration; (5) Sand Invasion or Penetration; (6) Desiccation; (7) Soil Denudation and Gully Erosion.

With the air cleared of any misunderstanding as to what is meant by erosion and drought the problem resolves itself into the proposition that erosion in any of its forms adversely affects the water supplies in the soil, springs, wells and rivers and the rainfall becomes capriciously intermittent. It follows then that the state of affairs in any given area can easily be assessed if it is known how these factors are progressing. There is a stage when the region is in a delicate state of oscillation as to its water supplies and its rainfall. From the practical point of view everyone concerned with the land should be able to recognize this stage because any further advance in the wrong direction makes it difficult, if not impossible, to reverse the process.

The author states that examples of this all important oscillating stage are only too plentiful but it is notable that the instances actually quoted are with one exception bordering upon desert areas. The recognition of this stage implies the investigation of water supplies and rainfall statistics. Records of the former for various districts in East Africa must be few and far between and not of long duration. One wonders, therefore, whether the obtaining of such records would be practicable on the grounds of cost and, if not, whether it is necessary to wait for them for much of East Africa in order to be able to assess what the position is with regard to erosion. In fact the example given of a deteriorated area in which in certain years, owing to rain

failure, the millet crop had to be sown ten times seems ample data for raising the alarm; and besides there must be plenty of other evidence on the ground if such is necessary. Practically it seems calamitous when the unfortunate grower has to part with probably half his past harvest in order to get his current crop growing, and one might be forgiven for expressing the opinion that the situation has already been allowed to deteriorate too far.

Why is it that many parts of Africa are in a serious position from erosion? The answer is interesting. It is that serious erosion is due to the methods of utilizing the land and these methods are supported, because permitted, by the Administration. It is held that the first and primary step must come from the Administration without whose action and support the advice of experts, committees and commissions is useless. It has been said elsewhere of this problem that "time is the essence of the contract" and in this paper "that to await the dawn of some problematic future when the educated African will take the necessary action himself is to risk either the migration (if possible) or starvation of no inconsiderable percentage of the population".

Of the suggestions which are given for dealing with the problem in Africa, and all of them are in themselves of a simple character, first place is given to the prevention by law of the promiscuous annual burning of the countryside. The strict observance of this regulation has been of enormous benefit to India. Evidently, if compared with India, shifting cultivation in East Africa is far more prevalent and it is scattered; added to this the herds of the pastoralists roam widely. Legislation without strict observance of it is useless and one of the chief difficulties one can foresee in these territories is to bring the offenders to book. Secondly a "regulated rotation farming and pasturing of stock" is needed. Through pressure of population and land hunger the soil becomes overcropped without sufficient time for natural recovery, particularly where shifting cultivation is in vogue. With the greater demands put upon it, the soil is finally reduced to a barren waste. The same end is reached where stock is the main concern if grazing and numbers are unregulated. The author admits that "protective and ameliorative works may often be of a simple character—though their introduction amongst a population unused to restrictions may prove a matter of some difficulty". Reclamation of badly eroded areas is obviously to be regarded as expensive work and not to be compared with the cheaper and quicker remedial measures.

In considering research work it is advocated that it should first of all be confined to water supplies and, since the unit of administration is the district, this investigation will provide the district officer with a statement showing the areas of erosion and the degrees of it in his district. Attention is drawn to the useful research in the Sudan on the local grasses to improve the grazing areas there.

Authorities responsible for the reclamation of areas from the tsetse fly are warned of the risk of erosion attaching to the clear felling of trees and undergrowth. It is feared that such destruction of vegetation is bound to have the same evil effects on water supplies as similar clearings by the agriculturist.

It is said that erosion carried to its logical conclusion is desert, and it is because the meanings of the words erosion and drought are not properly understood by many people that Professor Stebbing has written this paper. It gives a com-

prehensive and clear picture of those factors and practical issues which are entirely changing the economic conditions of vast tracts of country and it should be read by everyone connected with the land.

R. M. D.

HERE'S HOW; HINTS FOR THE MAN "IN THE BLUE", by J. St. J. Orde Browne, Pub. East Africa Ltd. 1937. Price 5/-.

When asked to review this book, I agreed with alacrity, having visions of a few pleasant and instructive evenings spent in learning more about my favourite pastime. But I was disappointed. The book does not, as I had hoped, do for Africa what Morton Shand and Norman Davey have so ably done for Europe; in fact the first mention of my hobby that I found was the somewhat familiar though doubtless sound observation that "Alcohol is best taken in strict moderation, and, as a rule, not until the evening". Further perusal, however, revealed the interesting information that a Pipe of Port is 115 gallons, whereas a Pipe of Marsala is only 93 gallons. And a Puncheon of Brandy is 120 gallons. But I have never been able to afford to buy my brandy by the puncheon, nor even by the firkin (the smallest measure quoted) which is 9 gallons.

According to the publisher's "blurb", this book will teach you almost anything from how to destroy cockroaches to the building of a house. Actually two of the formulae given for poisoning cockroaches are, in my experience, of very little use against East African species, while the directions for building a house appeared as inadequate to me, with no knowledge of the subject, as they did to a professional to whom this chapter was shown.

But it is easy to criticize a book of this nature. If it were to contain all the information that a man in the blue might require, it would have to consist of five or more large volumes, and this book does give, in the space of some 180 pages, a great number of valuable hints. Moreover it has an adequate index, a most desirable but all too uncommon feature.

For in spite of the spread of the Scout movement, it is frequently apparent that many people do need a book that will tell them how to tie a reef knot instead of a granny, how to replace a blown fuse or a worn-out tap washer, or how to lay out a right angle. Moreover the author has disarmed criticism by stating in his preface that the book is not intended to be a technical work in any sense; he also invites corrections and suggestions, of which a few may not be out of place here.

The chapter on elementary surveying is readily intellgible and probably tells one all that is possible without the use of instruments or a knowledge of trigonometry. A table giving the difference between magnetic and true north and its average annual variation, for a few places in Africa, should be added. The method given for finding the north without a compass by means of a watch is useless anywhere in the tropics.

In the section on knots, a clove hitch might have been included. And what *are* "the usual knots" which "are very well known", when it is considered, and rightly, that a reef and a bowline require description?

It is a libel on the railways of East Africa, the Sudan and Egypt, though I cannot speak for others in Africa, to say that "insect powder may prove very welcome on a journey".

Surely the examples on pp. 170-171, apparently taken from a child's arithmetic book, are not worth including?

The statement on p. 175 that normal blood heat is 35.8°C. might lead to an unnecessary consumption of quinine. It is actually 36.9°C.

With these and other corrections, a fuller treatment of certain sections—notably those on electricity and travel notes—and with a list of references to easily accessible works where more technical and detailed information may be found, a second edition of this book should find a ready sale among those who cannot, or do not wish to, be continually calling in the services of the nearest *fundi.*

T. W. K.

GREEN MANURING — TWO IMPORTANT FACTORS AFFECTING SUCCESS, by S. D. Timson and H. C. Arnold, *The Rhodesia Agricultural Journal,* Oct. 1937.

Green manuring is either a difficult art or an almost impossible science. The character of the soil, the distribution of the rainfall, the growth of the green manure crop, the time of ploughing the green manure, the state of maturity of the crop, the time of planting the following cash crop—all these factors affect the success or otherwise of green manuring. Compared with the operation of green manuring the use of compost or farmyard manure is almost foolproof: the chief difficulty in the latter case usually is the absence of sufficient manure, especially where large acreages are being devoted to the cultivation of grain crops, and it is on the larger farms that green manuring is chiefly needed to assist in maintaining the organic matter content of the soil.

In Kenya Colony green manuring has given results varying from an apparent decrease in yield to an increase over control of about six bags of maize per acre. In the drier maize growing areas little or no success has attended green manuring.

The article under review reports the results of experiments carried out to test the effect on the following maize crop of ploughing under a crop of sunn hemp at various times between February 21st and April 21st. The maize was planted on November 29th, the rain which fell in the intervening period being negligible in amount. As might be expected the plots which were ploughed last gave as much as three and a half bags or 25 per cent more than the plots which were ploughed first and which had been leached by 7.48 in. of rain.

It has been recommended by the Department of Agriculture in Kenya for many years that farmers should not plough in green crops so early that there is a risk of the nitrates formed from the decomposing material being leached out of the soil before the maize is planted; in fact it has often been recommended that the "long term" green manure crops should be ploughed under only two or three weeks before planting the maize crop if the equipment on the farms makes this policy practicable.

It is unfortunate that it is not stated in this article whether the yields on the plots ploughed at different times showed differences which were significant *statistically,* although the design of the experiments appears to have been such as would have permitted statistical interpretation.

A second experiment is recorded which showed that increasing the seed rate of sunn hemp from 20 lb. to 60 lb. gave an increase of the yields of maize from the following crop. The maximum increase was 1.87 bags per acre or 11.12 per cent and here again no statement is made as

to whether the increase is significant by the tests applied by statistical methods.

However, the necessity to use a sufficiently high seed rate of the green manure crop to enable the green crop to smother weeds and to give a good bulk of material for ploughing under should be axiomatic amongst farmers.

Ploughing under the whole crop of sunn hemp—the weight of material is not stated—gave an increase of 1.94 bags of maize per acre in the succeeding crop compared with the crop following the stubble ploughed in at the same stage. Here again an increase was to be expected in view of the larger amount of organic material which was added but there is no mention as to whether the increase was statistically valid. C. M.

Land Usage and Soil Erosion in Africa. Supplement to the *Journal of the Royal African Society*. January 1938, pp. 19.

It is not often that a number of distinguished masters of agriculture and forestry assemble to give their views on a particular topic at a public function, yet this happened at a dinner of the Royal African Society presided over by the Parliamentary Under-Secretary of State last December. The above paper reports *in extenso* speeches by Sir Frank Stockdale, Sir Daniel Hall, Professor Stebbing, Professor Troup and Mr. Nowell. The discussion was the outcome of a strong resolution passed by the Council of The Royal African Society.

Sir Frank Stockdale introduced the discussion with a review of the measures that are being taken to control erosion in the British possessions of Africa. The problem seems to take on a different aspect as each territory is reviewed: in Basutoland the people have left the plains and taken to the hills which they are devastating; in Nyasaland they are destroying the forest; in Northern Rhodesia primitive people have taken to the plough; elsewhere stock are the main concern and so on. Sir Frank Stockdale is of the opinion that the situation can be saved in the agricultural districts and the real difficulty to be faced is in the pastoral districts, where rotational grazing will have to be introduced and increased water supplies provided. He emphasizes that three things must be kept in mind when dealing with the erosion problem. Can anything be done? If, as in some parts, it would cost too much and there is room to move the people it is better to abandon the area and set up afresh and adopt proper methods against erosion in the new area. Secondly, what is it that the people themselves would be able to accept without too great an interference with their lives and with their economics? Thirdly and most important: How can we gain the confidence of the people themselves in order that they will do work and help themselves? He points out that the question of soil erosion is but a fraction of the whole agricultural question; the distinctive feature in evolving a better agriculture is the idea of bringing everybody from the Governor downwards to bear on it; and it has to be realized by everyone that the basic problem of Africa is a better agriculture. For practical purposes the unit is the district and the officer in charge of it should be regarded as the estate agent, with technical officers to assist him with the work.

Sir Daniel Hall considers that Africans must be taught not only how to take action against erosion but how to improve and maintain the fertility of their soil. Crop rotation, cattle manure and composts are the methods for achieving

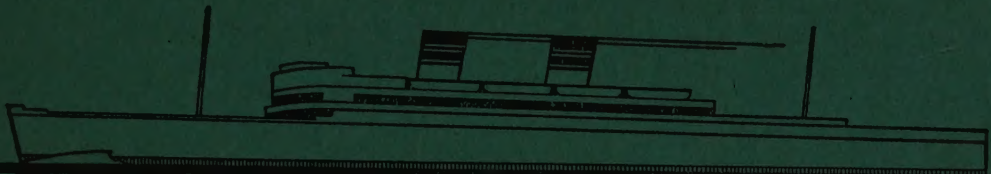
this and the African must learn to mould his present system to include them. He must also be forced to realize that he cannot continue to devastate the country by keeping numbers of uneconomic live stock.

Professor Stebbing would like to see a policy that would regulate farming practices and this can only be when the higher authorities realize the position of affairs and put an end to practices such as burning the countryside every year and ruthless destruction of important forests. Such a policy has been pursued by the Government of India and it has had marvellous results. He describes the fateful results to the water supplies and disturbance of the normal rainfall following upon mis-utilization of the soil and erosion.

Professor Troup draws attention to the relation of forests to water supplies. Trees growing on level ground may drain the upper layers of the soil of water but they do not affect the deep-seated supplies; whilst in hilly country they hold up the rain-water by preventing run-off and regulate the flow of streams and rivers. He holds that a study should be made of the uses to which land is to be put. Some land is more fit for forest than for any other use and there should therefore be a demarcating of the country into forest areas and agricultural areas. An instance is given of the serious effects of clearing unstable soils of tree growth and giving them over to shifting cultivation. Such areas should be left under a cover of tree-growth and encroachment is unnecessary if the agriculturally suitable areas are properly farmed to maintain fertility. Over-grazing is regarded by Mr. Nowell as being the most difficult erosion menace that East Africa has to face because so far no satisfactory counter to it has been applied. The problem resolves itself into ways and means of limiting the number of cattle that natives may be permitted to own. Although a great deal can be done by making more water supplies available, by rotational grazing and by improving the pastures, these are only temporary devices, the difficulty being that the stock population is multiplying at the rate of 20 per cent a year.

One may conclude from these speeches that, if the gravity of the situation was not being sufficiently appreciated before, it is so now, and that for agricultural land satisfactory progress in evolving anti-erosion methods has been made. As for pastoral land, if restriction of numbers of stock is a solution to the over-grazing problem it is difficult to understand why it cannot be implemented. Restriction in production is a common enough policy to-day to preserve the producer from disaster and it gives a sense of security to the economic scene. How much more excusable is it to avert disaster and give a similar security to the pastoral scene? And after all we have to realize that erosion is only a fraction of the problem we have set before us.

R. M. D.



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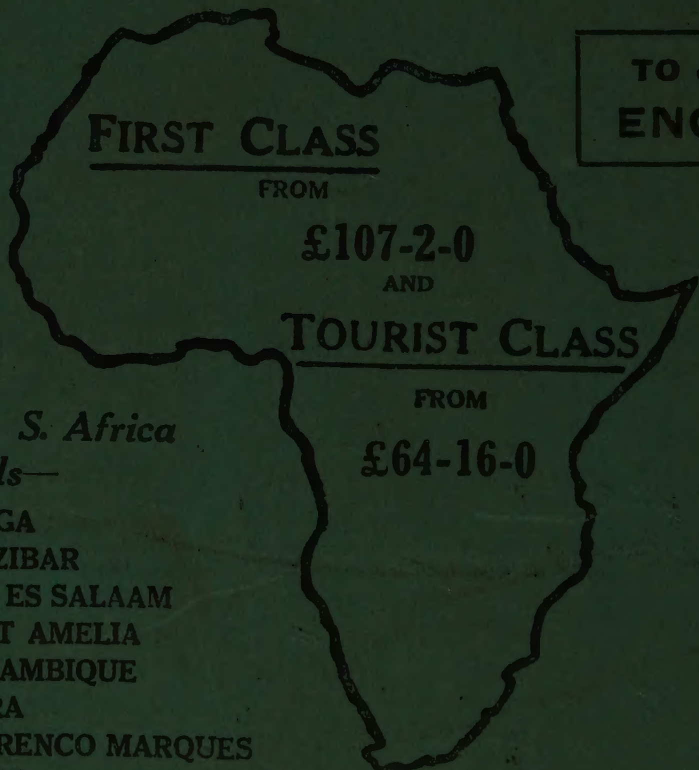

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